AN ECONOMETRIC ANALYSIS OF CONSUMER DEMAND IN FLORIDA

By

ROBERT L. SHEEHY

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF
THE UNIVERSITY OF FLORIDA
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE
DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

1977

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To

GRISELDA

and to

BRIAN

ACKNOWLEDGEMENTS

I wish to express my gratitude to Professor Jerome W. Milliman and to the other members of my committee for their continuous support and assistance. Special thanks are also due Douglas Scott of the International Monetary Fund for his encouragement of this study during a critical period. I also wish to thank Thomas Walter for computational assistance and Prabhavathi Job for her very efficient typing of the final draft. My deepest appreciation is due to my wife, Griselda, who typed several preliminary drafts, and provided constant encouragement and inspiration. Without her support, this project would not have been accomplished.

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Abstract of Dissertation Presented to the Graduate Council
of the University of Florida in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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By

Robert L. Sheehy

December 1977

Chairman: Jerome W. Milliman
Major Department: Economics

Responsiveness of consumers in the State of Florida to price and income changes is hypothesized to differ from the national average. To test this possibility, a quarterly data series on personal consumption expenditures in Florida is developed for nine major commodity groups on the basis of secondary sources, primarily retail sales information. These data are analyzed in the context of the linear expenditure system, and corresponding estimates are derived for the United States as a whole. Particularly significant variation between the two regions is found with regard to income and price elasticities of demand for clothing and shoes, housing, transportation services, and food and beverages. It is suggested that these differences are consistent with a priori expectations, and that they stem largely from characteristics specific to Florida, such as climate and the age structure of the population.

Partly in order to test the robustness of these results, a partially dynamic version of the linear expenditure system is also applied to the basic data series. This form of the model depicts the consumer as modifying present period budget allocation decisions on the basis of the carry-over effect of stocks or habits built up during previous periods. Empirical results within this context are not entirely satisfactory, but do tend to corroborate differences between Florida and the United States that were apparent in the original form of the model.

Finally, techniques derived from the theory of optimal control are applied to formulate a fully dynamic version of the model, in which the consumer is viewed as choosing an optimal path of purchases rather than a single optimal bundle at one point in time. Efforts to derive estimating equations for this form of the model are unsuccessful, as insufficient criteria are available to distinguish between its two possible solutions.

CHAPTER I
INTRODUCTION

Empirical studies based on models of consumer behavior, whether in the form of single equations or complete systems, have been applied extensively during recent years. Investigations have been carried out with respect to all major industrialized nations, and for many developing nations as well. The number of such studies has been particularly voluminous for the United States, perhaps because of the easy availability of relatively reliable data on personal consumption expenditures. In contrast to the plentiful amount of empirical work on the national level, very little has been done in the investigation of consumer behavior patterns and responses within particular states or subregions. There are two principal reasons for this neglect. The most important of these is the lack of regional data that are sufficiently comprehensive to permit the application of empirical techniques. The second is the lack of interest by practicing economists, at least until relatively recently, in the analysis of regional models of consumer behavior.

The Need for Regional Models

The pattern of consumer expenditures varies substantially from region to region across the United States and from country to country around the world. Such factors as climate, age, composition of the population, income levels and distribution, urbanization and relative dependence on certain industries exert important influences on consumption allocation decisions. Precisely because of the regional variation of these and other factors, economic estimates from a national model may not be applicable to individual subregions. The national estimates will be valid in general only for the country as a whole, since they represent an analysis of aggregate data and involve the loss of considerable information about individual states and regions. The more any subregion within the nation varies from the national average with respect to a wide number of variables, the greater the differences that may arise between local patterns of expenditure response and their national counterparts.

The existence of such differences can have significant implications for the effectiveness of a given economic policy within a particular region. The imposition or change in rate and structure of a sales tax, for example, will differ in impact according to the degree of sensitivity of consumers with respect to the resulting movement in the tax-inclusive price of affected items. Various forms of surcharges on particular activities, such as a commuter tax on suburbans using public transit to travel to work in a downtown area, will result in different responses and degrees of effectiveness depending on the elasticity of demand for the service in question. The overall effect on demand of any local government tax policy affecting prices or incomes will vary according to the local elasticity of response to these changes. The course of future economic activity in a given region will also be sensitive to regional differences in this regard. Economic growth in a particular area may be largely self-sustaining, or may require substantial doses of outside capital, depending on whether the income elasticity of local demand for goods produced within the area is large or small. Knowledge of the pattern of economic response in a given region, and of whether or not this pattern exhibits any specific regional characteristics, is therefore of primary importance in the formulation of economic policy by local and regional governments. The success or failure of such policy may depend on whether or not these specific characteristics have been taken into consideration.

The state of Florida has a number of distinctive economic characteristics that make it difficult to generalize about its economy from studies based on other areas or on national totals. A larger proportion of older and retired persons live in Florida than in most other states, and in addition, the importance of tourism and the mildness of the Florida climate are also attributes that make the state quite different from many other regions of the country. The physical characteristics of the state, its long sea coast and largely rural character in many areas, also make it a special case. The fact that Florida does differ so markedly from other areas of the United States in these and other respects might be expected to lead to definite differences between the behavior of Florida consumers and that of the average U.S. resident.

From a more formal point of view, there are basically two reasons why generalizing from the results of macro-area analysis may lead to misleading conclusions about a subregion such as Florida. First, the macro parameters may not reflect those of the subregion due to aggregation bias in the formulation of the data series.[1] Second, even in the absence of aggregation bias, too much information may be lost in the aggregation process to enable application to particular regions of the results from analysis of the macro area as a whole.

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[1] The usual meaning of aggregation bias is the problem of correspondence between micro-economic and macro-economic parameters when the

Aggregation Bias

It has been demonstrated ([21], [23]) that, in the case of a function with m independent variables, consistent aggregation is possible only if the function under consideration is linear in nature. Even in this instance, aggregation bias may be expected to occur unless certain rather stringent conditions are met. This may be seen through the following demonstration. Consider the stochastic regional relationship.

$$y_r = a_r + \sum_{i=1}^{m} b_{ir}x_{ir} + u_r \qquad (1)$$

where:

y_r = The regional value of the dependent variable, e.g., consumption expenditures in Florida.

x_{ir} = The regional value of each of the set of m independent variables, e.g., Florida personal disposable income.

a_r = The regional intercept.

b_{ir} = The regional coefficients of the set of m independent variables.

u_r = The random disturbance term entering the regional relationship.

If there are n regions in the macro area, the aggregate dependent variable for the entire area will in general be the sum across regions of the local values of these variables, so that

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micro-economic variable is the individual behavioral unit. Although the present case involves the relationship between two macro-economic units, one of which is a component of the other, the problem is formally identical to that of aggregation bias, and has been so treated here.

$$Y = \sum_{r=1}^{n} y_r \tag{2}$$

The correct specification of the relationship corresponding to statement (1) for the macro area as a whole may then be expressed as:

$$Y = \sum_{r=1}^{n} a_r + \sum_{r=1}^{n} \sum_{i=1}^{m} b_{ir} x_{ir} + \sum_{r=1}^{n} u_r \tag{3}$$

The double summation over r and i implies that general conclusions about the individual b_{ir} may not validly be drawn from the usual procedure of regression of Y on a set of aggregate independent variables formed by summation of regional independent variables, i.e., as

$$X_i = \sum_{r=1}^{n} x_{ir} \tag{4}$$

A regression utilizing the varibles (4) as regressors is misspecified in terms of the regional variables, as it ignores the implicit weighting of regional independent variables that is involved when the summation is across the product $b_{ir} x_{ir}$ [63].

In addition to this difficulty, further problems may also arise if there is a feedback relationship between the regional and macro variables. To illustrate this, assume that the regional variables, x_{ir}, may be stated as linear functions on the corresponding aggregate variables for the macro area of which the region is a part:

$$x_{ir} = \alpha_{ir} + \sum_{j=1} \beta_{ir.j} X_j + \varepsilon_{ir} \tag{5}$$

where α_{ir}, $\beta_{ir.j}$, and ε_{ir} are the intercept, slopes, and a random term respectively, and the X_j are the macro variables in question. Note that equation (5) is consistent with statement (4) only if,

$$\sum_{r=1}^{n} \alpha_{ir} = \sum_{r=1}^{n} \varepsilon_{ir} = 0$$

and if,

$$\sum_{r=1}^{n} \beta_{ir.j} = 1 \quad \text{if} \quad i = j.$$

$$\text{and} \sum_{j=1}^{n} \sum_{r=1}^{n} \beta_{ir.j} X_j = 0 \text{ if } i \neq j$$

Substituting (1) and (5) into (2) and simplifying, we obtain,

$$Y = \sum_{r=1}^{n} (a_r + \sum_{i=1}^{m} b_{ir} \alpha_{ir}) + \sum_{i=1}^{m} \left(\sum_{r=1}^{n} \sum_{j=1}^{m} b_{ir}\beta_{ir.j} X_j \right) +$$

$$\sum_{r=1}^{n} (u_r + \sum_{i=1}^{m} b_{ir} \varepsilon_{ir}) \qquad (6)$$

Except for the terms,

$$\sum_{r=1}^{n} a_r \; ; \quad \sum_{i=1}^{m} \sum_{r=1}^{n} \sum_{j=1}^{m} b_{ir}X_j \; ; \text{ and } \quad \sum_{r=1}^{n} u_r,$$

all other elements of equation (6) are an additional form of aggregation bias resulting from the existence of the feedback effect of equation (5).[1] It may also be noted that all of these additional biases may be expressed in terms of covariances. Thus, for the case where equations (5) and (4) are consistent, the biases from aggregation affecting the intercept, the slopes and the error term, respectively, are simply the covariances,

---

[1] To separate the aggregation bias of the middle expression of equation (6) for the case where statements (5) and (4) are consistent, rewrite the expression as:

$$\sum_{i=1}^{m} \sum_{r=1}^{n} \sum_{j=1}^{m} (b_{ir} + b_{ir} (\beta_{ir.j} -1)) X_j$$

$$n \sum_{i=1}^{m} \text{cov}\ (b_{ir,}\ \alpha_{ir})\ ;\quad n \sum_{i=1}^{m} \text{cov}\ (b_{ir,}\ \beta_{ir.j});\ \text{and}$$

$$n \sum_{i=1}^{m} \text{cov}\ (b_{ir,}\ \varepsilon_{ir}).$$

If all three types of aggregation bias occur, it will be impossible to obtain even consistent aggregation. If, however, $\text{cov}(b_{ir,}\ \varepsilon_{ir}) = 0$ for all periods, aggregation will be consistent, although still biased. Note, though, that aggregation will be completely unbiased only when all three covariance terms drop out of the equation. One obvious instance where this occurs is when all of the b_{ir} are homogeneous across regions, i.e., when there is no regional variation in the slope estimate. Such homogeneity will also eliminate the misspecification error implied by use of the aggregate variable of statement (4).

The existence or nonexistence of such variation across regions is essentially an empirical question. As demonstrated in subsequent chapters of this study, there appears to be considerable evidence that homogeneity does not exist between the parameters that apply to the state of Florida, the object of the present study, and those affecting the national entity of which it is a part, the United States.

Loss of Information

Even if problems of bias from aggregation are nonexistent or are so small that valid aggregation may still be performed, the resulting macro parameters are still not easily translated to their regional correspondents. The arithmetic mean of the macro intercept, for example, is not necessarily equal to any of its regional constituents. Similarly, the slope of the macro relation, even though it is the weighted mean of the corresponding regional slopes, is not necessarily equal to any one of them. In fact, the macro slopes and the arithmetic mean of the macro intercept will in general equal their regional counterparts only in the very special case where all parameters are equal across regions, and where no regional variation may be noted.

Whether or not the amount of information loss is sufficient to be of concern is again an empirical question. A comparison of results from the analysis of data for Florida and the United States appears to indicate that, even if aggregation bias is not a problem, some difficulty remains due to a loss of information through averaging.

Goals of this Study

The present study attempts to remedy in some measure the paucity of analysis of regional consumer behavior patterns. Data on the allocation of consumption expenditures in the state of Florida are developed, principally on the basis of retail sales information. These data are then analyzed within the framework of a static model of consumer behavior, and the results are compared with corresponding parameter estimates for the United States as a whole.

The study also attempts to analyze the data in the framework of a dynamic model of consumer behavior. The static model is extended to incorporate certain dynamic elements, and estimates of Florida behavioral parameters are again obtained. Finally, in an appendix, a fully dynamic model of consumer behavior is derived that views the consumer as optimizing an entire time path of expenditure, rather than allocating his budget on the basis of prices and income prevailing at a single point in time.

The structure of the study is as follows. Chapter II describes the development of data on personal consumption expenditures in Florida. In Chapter III, a static model of consumption decisions is presented and applied to this data base and to corresponding data for the United States as a whole. A partially dynamic extension of the model and the associated empirical results are presented in Chapter IV, future directions for research are outlined briefly in Chapter V, and preliminary work on a fully dynamic extension of the model is reported in an appendix.

CHAPTER II

THE DATA[1]

The purpose of this chapter is to describe the development of information concerning personal consumption expenditures (PCE) in the State of Florida, the region that forms the basis for this study. Before the present project, no information was available about consumption expenditures in Florida. A prerequisite to the study was therefore the development of an accurate time series for consumption expenditures by Floridians within several major commodity categories. Given the size and timing of the project, a comprehensive individual survey of consumer expenditures in Florida was not feasible. Such a survey would have permitted a much more detailed study of Florida consumer behavior, and might have resulted in a more accurate data series as well. Unfortunately, the cost of a direct canvassing of individual consumers on the required scale was prohibitively expensive, and it was necessary to compile the basic data series from secondary sources.

The alternative data sources used were principally the records maintained by the Florida Department of Revenue on gross and taxable retail sales within the state for the period from July 1968 through December

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[1] This chapter is largely a revised version of some of the material presented in the report, Florida Personal Consumption Expenditures for the Final Demand Sector in the Florida Inter-industry Model, by Robert L. Sheehy and Jerome W. Milliman, Bureau of Economic and Business Research, University of Florida, mimeograph, December 1975.

1973. The specific difficulties encountered in derivation of the data series were in large part determined by this choice. Techniques had to be developed to permit the estimation of consumption magnitudes from the retail sales information, and the series had to be reclassified to be consistent with the requirements of a model of consumer behavior. Attempts have been made to apparaise the accuracy of the resulting data series, and the various expenditure estimates have been compared with corresponding U.S. magnitudes. The separate stages of this process are described below.

Personal Consumption Expenditures

Personal consumption expenditures (PCE) may be defined as the market value of final goods and services purchased for use by individuals or by nonprofit institutions rendering services to individuals [68]. For completeness, this must also include the value of goods and services that are received by individuals as income in kind, even though these latter commodities are not "purchased" in the conventional sense. Items of personal consumption expenditure accordingly include all items destined for direct use by the individual consumer. This classification accounts for by far the largest component of national output as measured by Gross National Product, and is normally in excess of 60 per cent of total demand for production [67].

An important distinction exists between personal consumption expenditures and the total of all expenditures by consumers. The latter includes a variety of items that do not fall into the category of personal consumption. Any purchase of items whose expected lifespan exceeds one year should be considered as an investment rather than as personal consumption, while the value received from the use of the items during a given period is more properly an element of consumption. The most obvious example of such purchases is expenditure for housing. In this case, the amount spent for the structure itself is clearly an investment, while the value of services received during any given period should be counted as consumption. A similar difficulty arises with respect to any durable good, in that purchases during a given period are not an accurate reflection of consumption services received. This problem will be more serious as the product is more durable.

This issue has been largely ignored, and no attempt has been made in the national accounts to differentiate between the investment and consumption components of many purchases. An exception is made in the case of housing, where consumption and investment transactions involve such widely divergent values that the national consumption accounts do include an imputed value for housing services. The present study also largely abstracts from this complication for two reasons. First, it is desired that definitions of consumption expenditure categories on the state level correspond to their respective national counterparts; and second, the shortage of data for dealing with the problem is even more acute on the local than on the national level.

State Estimates of Personal Consumption Expenditures

State consumption data in general are so scanty as to be almost nonexistent. Very few states have even secondary estimates available for personal consumption expenditures within their boundaries, and the methodology used in derivation of many of these estimates is not very sophisticated (e.g., see [37]). Even the more elaborate attempts to derive state PCE estimates have often been no more than specific applications of the results of national consumer expenditure surveys [39]. As interest in regional economic conditions has increased in recent years, more complete regional accounts have become desirable. Several efforts are currently under way to improve the quality and availability of state estimates of personal consumption expenditures.[1] Even so, state PCE series based on primary data are virtually nonexistent.

There are several reasons why the construction of state consumption series has not depended on primary data. Very few states have data available that lend themselves to the estimation of purchases for use by individuals. Thus, special surveys often must be undertaken. This totally eliminates the possibility of developing time series information that can be used in the short run, as it is extremely difficult to extend such a series backward in time. Moreover, the cost of such a survey is extremely high, and there is no guarantee that the improvement in data quality will justify the increased expense. Even when existing data are available from which secondary estimates of personal consumption expenditures may be made, a quite complicated process is often required since the available statistics were generally not collected for this purpose. The result has been a general paucity of data with regard to personal consumption expenditures on the state or regional level.

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[1] Dr. S. O. Park of the U.S. Department of Commerce is currently engaged in an attempt to estimate PCE series for all 50 states on the basis of regional differences in income and age structure.

One of the best sources of data for the development of state consumption figures is the information about retail sales taxes available in most states where such taxes exist. These taxes are levied against a variety of items purchased by consumers and form a solid foundation for the derivation of consumption expenditure estimates. The process remains fairly complicated, however, and involves several significant problems. Coverage of sales taxes varies widely across states and across time in terms of both comprehensiveness and consistency, and the tax data thus are often unsuitable for the estimation of consumption patterns. If the tax is applied to only a limited number of items, the data base may be too small to give meaningful results. Frequent revisions of the base and rate of the tax may also reduce the usefulness of the series. In addition to these difficulties, sales tax data include taxes on a variety of expenditures by businesses and tourists that are not personal consumption expenditures by residents of a particular area. Finally, data based on retail sales will still have to be supplemented by independent estimates of items such as educational services that are not subject to the retail sales tax laws. Independent estimates will also be required for consumption items such as space value of owner occupied housing, for which no actual purchase transaction has occurred.

A Data Base for Florida

The data used in the present study are based primarily on retail sales information collected by the Department of Revenue of the State of Florida for the period from mid-1968 through the end of 1973. Florida has a better data base for the construction of PCE estimates than many states because firms are required to report gross as well as taxable sales during the tax collection process. The availability of gross sales data is especially important in estimating purchases of consumption items such as food upon which no tax may be payable. Sales tax receipts and associated data on both gross and taxable sales are tabulated monthly by the Department of Revenue according to the type of establishment where the transactions have taken place, and are reported in a breakdown to 85 different establishment classes. Since this grouping is not consistent with an economic classification of expenditures, the original 85 groups were reclassified in this study into the eleven major expenditure groups utilized in the national income accounts (see [57]). These eleven categories are themselves a disaggregation of the three broad types of consumption goods: durables, nondurables, and services. They are briefly: automobiles and parts; furniture and household appliances; other durables; food and beverages; clothing and shoes; gasoline and oil; other nondurables; housing; housing operation; transportation; and other services.

The reclassification of the original 85 establishment groups to achieve consistency with the national income accounts involves several assumptions. Since data are not available on the product breakdown of sales within each type of establishment, each group was classified according to its principal product. This procedure is acceptable in many instances, since many firms (e.g., restaurants) sell products belonging almost entirely to a single one of the eleven expenditure categories. In general, however, classification of firms according to principal product may be justified only if it is assumed that the effects of overlapping goods will tend to cancel out. The more aggregated nature of the new commodity groups will tend to eliminate many of these misclassification problems, and fewer errors will be incurred in the series if further aggregated to the three major expenditure groups of durables, nondurables and services. There are of course some potentially important costs involved with such aggregation, including the probable loss of a great deal of information that is accurate about expenditures in certain groups. Analysis of the more aggregated expenditure groups is also much more limited in terms of the breadth of potential applicability to more specific commodity categories.

The reporting procedures of the Florida Department of Revenue are such that most retail sales for any given month are reported to the Department in the month following that during which they actually take place. To adjust for this lag, consumption for any given quarter has been considered to be reflected by the retail sales figures reported to the state during the quarter beginning one month later and extending one month longer than that in question. This adjustment does not allow for reports that are delayed for more than one month after the end of a quarter, but since such overdue reports are only a very small fraction of the total, the validity of the series as a whole is probably not significantly affected.

Inaccuracies in the reporting of sales statistics by retail establishments also present some difficulties. In particular, reports of gross sales, where no penalty exists for intentional inaccuracy, may contain some misstatements, especially in the case of smaller firms, which ordinarily have less resources to devote to full reporting compliance. Such reporting inaccuracies would have potentially severe distorting effects on commodity categories where nontaxable sales are a relatively large component.

Fortunately, such groups are comprised mainly of industries where large firms account for the bulk of industry sales, and such firms ordinarily have had a fairly reliable reporting record.

Intermediate Goods

Another difficulty stems from the fact that many transactions at the retail level do not involve final consumption goods but rather products used by business concerns as inputs into the production of final goods and services. Since the Florida sales tax is for the most part applied only to goods sold to the final user, the greatest part of such sales are nontaxable. Most such intermediate goods can therefore be eliminated by utilizing only taxable sales as a measure of consumption expenditures within any given establishment group. Exceptions must be made for establishments such as grocery stores, which make large amounts of tax-exempt sales of consumption items. Since most tax-exempt sales of consumption goods are made by firms selling only insignificant amounts of intermediate products (e.g., drug stores), gross sales are probably a reasonably accurate measure of consumption expenditure in these cases. Some more specific problems in the elimination of intermediate goods will be discussed later.

Tourist Expenditures

Tourist expenditures are an important component of some retail sales categories in Florida. Such expenditures must be netted out in the estimation of local consumption expenditures by Florida residents. Unfortunately, while scattered estimates of tourist expenditures in Florida are available from several sources for different specific years, there is no existing series that is satisfactory for purposes of the present study (see [16], [40], [70]). Accordingly, a quarterly time series of tourist expenditures was derived on the basis of an estimate by the U.S. Travel Data Center of average daily expenditures by tourists in Florida during 1972 [70]. The original estimate was derived from the 1972 National Travel Survey of the U.S. Department of Commerce. A time series of such average expenditures was formed by assuming that average expenditure per day per tourist was the same proportion of average U.S. per capita income in all periods as it was in 1972. It was also assumed that the average length of stay by tourists in Florida during the different quarters of 1972 was an accurate reflection of their stay during other periods. The estimated expenditures per day per tourist were then combined with the average number of days per quarter to approximate the amount spent per quarter per tourist. This latter figure was multiplied by the number of tourists per quarter (Florida State University estimates) to obtain aggregate expenditures by tourists in Florida each quarter. The derivation of this aggregate total may be described more specifically as follows:

$$E = T \cdot S \cdot D,$$

and $D = a\,(Y_{us})$

where E = aggregate tourist expenditures in Florida in a given quarter

T = number of tourists in that quarter

S = average length of stay in that quarter

D = average total expenditure per tourist per day

a = factor of proportionality derived as described above

Y_{us} = per capita income in the United States for the quarter in question.

Total tourist expenditures were then allocated as follows among the various product groups. It was assumed that tourists in Florida purchase a constant real bundle of products, the proportional distribution of which was assumed to be that reflected in the 1972 study by the U.S. Travel Data Center [70]. A price index was then constructed for tourist expenditures with the 1972 expenditure proportions as weights. Total expenditures by tourists in Florida were then deflated by this index and the resulting real total was allocated on the assumption of constant real proportions. Nominal expenditures within each product group were then calculated by allowing price movements to be reflected.

The major limitations of the series are the assumptions that tourist expenditures per day are linked to U.S. per capita income, and that the average number of days spent in Florida in each quarter of 1972 is representative of other years as well. These weaknesses are probably not too serious as long as the series is not extended too far away from the year of reference. In any case, comparable estimates are presently being developed for 1974 by the U.S. Travel Data Center. These estimates will allow the series to be updated with more accuracy from that date. In addition, as further estimates are made in the future, a continued fairly reliable estimate of tourist expenditures in Florida will be possible.

Development of Individual Series

Although most consumption expenditures are included in retail sales data, there are several substantial subsectors of services that do not appear as sales by retail establishments. Independent estimates were therefore made of such items. Each of the eleven principal expenditure classes involved special problems of data inconsistency or unavailability. These are discussed below.

Automobiles and parts. This category is defined by the Department of Commerce as including purchases of new cars, tires, tubes, accessories and parts. Net purchases of used cars (i.e., the margin between buying and selling prices for dealers in used cars) are also included. This latter component is normally quite small, since most used cars are received as trade-ins on new cars and are often sold for less than or close to their trade-in value. Estimates of consumption expenditures in this category were formed entirely from the retail sales data base with several adjustments. Such items as the leasing of rental cars and charges for repair services by new-car dealers were reclassified as transportation services. Sales of used cars were netted out to avoid double counting since such sales do not represent new consumption, but rather a reallocation of consumption among different individuals. The adjustment was in each case based on results of a recent study by the State Department of Revenue of sales tax collections within the motor vehicles category. In accordance with these results, approximately 10 per cent of the original total allocated to automobiles and parts was reallocated to transportation services, and about one-third of total automobile sales by the motor vehicles group was judged to be composed of used cars.

Furniture and household equipment. This group is broadly defined and encompasses nearly all nonautomotive durable goods. Examples include such dissimilar articles as mattresses, china and glassware, phonograph records, musical instruments, kitchen appliances and other furniture. Personal consumption expenditures within this group were estimated as the total of taxable retail sales in the various establishment groups in the category.

Other durables. This relatively minor category covers a wide variety of items not classified in either of the first two groups, including such things as sports equipment, pleasure aircraft, and orthopedic appliances. Estimation involved no significant problems and was based strictly on taxable retail sales.

Food and beverages. Both commercially prepared meals and food or beverage products sold for home consumption are included in this category. Almost all consumer expenditures in this group are covered by the retail sales data, with the exception of several minor items, the most important of which is the small amount of food and beverages produced on farms and consumed by the farmer himself. Estimates of this component are available from the U.S. Department of Agriculture,[1] and have been incorporated into the present series. Ideally, this category should also include food furnished to government and commercial employees as part of wage or fringe benefit packages. Unfortunately, no data exist on the amount of such payments in kind, and they have been excluded from present estimates. The magnitude of such imputed expenditures is very small even on the national level, and their exclusion is not expected to have adversely affected the validity of the estimates. An adjustment to the retail sales totals for this group was also required to allow for expenditures by tourists, which were estimated as explained above.

Clothing and shoes. This group includes clothing, shoes and related accessories. It also includes clothing issued to military and other personnel as an implicit part of their wage. Except for this latter category, which is quite small and has been ignored, estimation of personal consumption expenditures in this group was made directly and without modification from the retail sales data base.

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[1] See the personal income intermediate level table of the U.S. Department of Commerce [69].

Gasoline and oil. Expenditures within this category were estimated directly from retail sales data, after adjustment for tourist expenditures for gasoline and oil.

Other nondurables. This category includes a wide variety of items not classified elsewhere, such as tobacco, drugs, cleaning supplies, nondurable toys and paper products. Estimates of consumption expenditures in this group were based on the retail sales data, after adjustment for tourist expenditures. Estimated intermediate sales of certain primarily construction-oriented establishments such as lumber yards were also netted out, on the basis of a study by the State Department of Administration of the relationship between construction sales and documentary stamp tax receipts for various types of construction. All but about 15 per cent of retail sales by such establishments were accounted for by construction expenditures and were therefore deducted from the retail sales totals for purposes of the present study.

Housing. The distinction between the investment and consumption components of total personal expenditures is especially important in the case of housing. Purchases of structures are essentially investments, while the space-rental value associated with a structure is the portion of housing that may be consumed. An inconsistency exists in this regard in the treatment of mobile and modular homes in the national accounts. Although the housing services component of mobile home consumption is calculated in the same manner as for permanent structures, the purchase of the units themselves is included in the accounts as part of the consumption of automobiles and parts. This inconsistency has become more serious due to the increased importance of mobile homes as an alternative to more permanent units, and a revision of the national accounts is therefore being planned. In the present study, the convention currently prevailing on the national level has been followed, with purchases of mobile homes included as part of automobiles and parts and with the housing services provided by individual units included as part of housing.

Estimates of the nonmarket components of housing services consumption, i.e., the imputed rent of owner-occupied nonfarm housing and the estimated rental value of farm homes, were obtained from the Regional Economics Division of the U.S. Department of Commerce and from the U.S. Department of Agriculture, respectively. These two components comprise more than two-thirds of total housing services. Retail sales data on the monetary component of housing expenditure (rents paid for apartments and other rental units) are unsatisfactory for the estimation of personal consumption expenditures due to frequent base changes and the exemption of large portions of the rental population from the sales tax over the entire period in question [14]. In addition, many rentals are taxable for only the first year of occupancy by a given tenant and reporting problems often develop thereafter. Enforcement of the sales tax law in this area is also rather lax, since the state has no accurate method to trace the movement of tenants in and out of a given rental unit. Substantial and uneven underpayment of sales taxes on rental units has resulted.

Because of the inadequacy of the retail sales data, the monetary component of local housing expenditures was based on estimates by the U.S. Department of Commerce of monetary rents received as income to proprietors within the State of Florida. Use of these figures assumes that all rents paid by Florida tenants are received by Florida landlords and that no Florida resident receives rental income from outside the state. Although these assumptions are quite strong, to the extent that they are both contradicted, the violations will tend to cancel one another out. In any case, the total amount of dollars involved in interstate rental flows is probably rather small.

Housing operation. This group encompasses expenditures for all household utilities, including electricity, gas, water, sanitary services, telephone and other services that are entirely household-related. Estimation of consumption expenditures within this category was based primarily on the retail sales data, after adjustment of the utilities and communications subcategories to offset the effect of a substantial base change in the second quarter of 1972, when large exemptions were granted to some residential users. The ratio of taxable to gross sales before that time was applied to the data series on gross sales to derive what taxable sales would have been in the absence of the base change. These adjusted figures were then incorporated into the final series on household operation services.

One component of this group, domestic services, is not available from the retail sales data base. Imputed estimates of this item, as income resulting from private household services, have been prepared for Florida by the U.S. Department of Commerce and were incorporated into the present study.

Transportation services. Included within this category are all purchased transportation services, both local and intercity. Also included are user-operated transportation services, which are by far the largest single component of the group, including such items as automobile repair, parking and rental, and bridge, tunnel and road tolls. Personal consumption expenditures in this group were estimated entirely from the retail sales data. In addition to sales directly attributable to this function, car rentals and automotive repair services provided by motor vehicle dealers have been included as described above in the discussion dealing with automobiles and parts. Purchases of transportation by businesses constitute intermediate transactions and thus have been excluded.

Other services. This category includes all services not elsewhere classified and is of necessity rather heterogeneous. The largest single components are medical care, education, insurance, legal and personal services, admissions, and services furnished without pay by financial intermediaries. The calculation of consumer expenditures in this sector involved much more independent estimation than most other categories. In addition to an adjustment of the retail sales data for tourist expenditures, estimates of imputed interest in Florida were obtained from the U.S. Department of Commerce, and independent estimates were made of both legal and educational services.

Personal consumption expenditures for educational services are composed of direct expenses for private school tuition and for higher education. An estimate of private educational expenditures in Florida was available for 1970 from the work of Karen Polenske and her associates on allocation of gross national product among the various states ([48], [56]). To derive an estimated time series of such expenditures, it was assumed that the 1970 ratio of private to public consumption of educational services held constant throughout the period covered by the present study.

Statistics on public educational expenditures within the state were then used to derive estimates of private purchases in this area.

Estimates of expenditure for legal services were also based on the calculation for 1970 available from the work of Polenske. A constant ratio was assumed between personal consumption expenditures for legal services and the total number of lawyers practicing within the state. Estimates of the latter by the American Bar Association were then used to calculate the required series. Although the assumptions required for the accuracy of such a method are quite strong, the numbers involved in this sector are comparatively small, and the amount of error introduced into the total series is probably not large.

Undistributed. This category consists of components of the retail sales data base not amenable to categorization within any of the other 11 groups, but which clearly constitute consumption-type expenditure. Examples include taxable sales from establishments such as department stores, itinerant vendors, general merchandise stores, and other miscellaneous firms. Most of this group should probably be allocated to other durables, other nondurables, and other services, but no criteria presently exist for such an allocation. In the estimation of the behavioral model that will be examined later, all of these categories were combined into a single composite group.

Analysis of the Data Series

The following portion of this chapter is devoted to an examination of the validity and limitations of the data series described above, and to a brief comparison of Florida consumption patterns with those of the entire United States. Personal consumption expenditures in Florida are presented in Table 1 for the five years from 1969 through 1973. Although the data series was developed on a quarterly basis for the period from the third quarter of 1968 through the last quarter of 1973, annual figures are presented in the table to abstract from seasonal variations in presenting an overall picture of the pattern of consumer expenditure in Florida. With the few minor exceptions discussed above, the 11 categories of expenditure are broadly comparable to the major functional classifications used in the national income accounts. It is evident from Table 1 that the largest component of expenditure by Florida consumers is for food and beverages. This is followed in importance by the miscellaneous services category and by purchases of automobiles and parts. The undistributed group is also rather large, indicating that estimated expenditures for other durables, other nondurables, and other services should probably be further increased, since the undistributed group appears to be comprised largely by goods belonging to these categories.

There are substantial differences between the patterns of consumption expenditures in Florida and in the nation as a whole, as may be observed in Table 2. The proportion of total expenditure allocated to purchases of automobiles and parts is much higher in Florida, partly due to the unusually large numbers of mobile homes (the purchases of which are classified under automobiles and parts) that are used as forms of housing within the state. The lower space rental value associated with such homes also partially accounts for the relatively smaller expenditure for housing services in Florida. Expenditures for automobiles in Florida may also be due to higher average values as a result of the widespread use of air conditioners and other optional equipment. The greater proportion of total budgetary outlays

Table 1. Florida: Local Personal Consumption Expenditures, 1969-73

(In thousands of current dollars)

Product Group	1969	1970	1971	1972	1973
1. Automobiles and parts	1,619,834	1,704,334	1,957,082	2,690,902	3,180,260
2. Furniture, household equipment	921,702	968,901	1,121,340	1,305,120	1,730,190
3. Other durables	451,401	464,912	533,404	695,779	858,781
4. Food and beverages	4,343,131	4,849,069	5,245,600	6,163,842	7,107,697
5. Clothing and shoes	603,317	653,735	678,495	779,519	953,999
6. Gasoline and oil	886,629	992,055	1,075,634	1,194,408	1,306,995
7. Other nondurables	1,369,109	1,498,577	1,629,721	1,997,527	2,538,853
8. Housing	892,319	998,724	1,125,790	1,275,674	1,391,741
9. Housing operation	1,526,956	1,771,871	2,082,952	2,413,199	2,673,461
10. Transportation	365,645	353,687	438,866	641,783	790,198
11. Other services	2,026,217	2,335,297	2,607,856	3,095,751	3,746,125
12. Undistributed	2,086,840	2,305,870	2,649,000	3,143,090	3,766,180
Total	17,093,100	18,897,032	21,145,740	25,396,594	30,044,480

Table 2. Florida and the United States: Proportional Allocation of Personal Consumption Expenditures, 1969-73

Product Group[1]		1969	1970	1971	1972	1973
1. Automobiles and parts	FL	.0948	.0902	.0926	.1060	.1059
	US	.0694	.0604	.0699	.0728	.0714
2. Furniture, household equipment	FL	.0539	.0513	.0530	.0514	.0576
	US	.0640	.0641	.0634	.0668	.0683
3. Other durables	FL	.0407	.0378	.0392	.0423	.0436
	US	.0233	.0233	.0225	.0228	.0221
4. Food and beverages	FL	.2541	.2566	.2481	.2427	.2366
	US	.2081	.2105	.2037	.1971	.2050
5. Clothing and shoes	FL	.0353	.0346	.0321	.0307	.0318
	US	.0866	.0855	.0859	.0864	.0872
6. Gasoline and oil	FL	.0519	.0525	.0509	.0470	.0435
	US	.0361	.0359	.0352	.0343	.0351
7. Other nondurables	FL	.1225	.1218	.1199	.1214	.1291
	US	.0935	.0950	.0926	.0931	.0924
8. Housing	FL	.0522	.0529	.0532	.0502	.0463
	US	.1451	.1472	.1486	.1480	.1446
9. Housing operation	FL	.0893	.0938	.0985	.0950	.0890
	US	.0583	.0589	.0591	.0594	.0587
10. Transportation	FL	.0214	.0187	.0208	.0253	.0263
	US	.0286	.0296	.0306	.0299	.0291
11. Other services	FL	.1828	.1899	.1918	.1881	.1904
	US	.1867	.1894	.1883	.1892	.1862

Sources: Table 1, and Survey of Current Business [69].

[1] The undistributed category (group 12 in Table 1) has been allocated to groups 3, 7, and 11 for purposes of this comparison.

devoted to gasoline and oil in Florida is undoubtedly at least partly due to the larger amount allocated to automobiles and parts.

Other differences between consumption patterns in Florida and the United States are probably derived from climate and weather. Thus, lower relative expenditures for clothing and shoes are certainly related to some extent to the mildness of Florida winters, while higher expenditures for housing operation are partly due to the heat and humidity of the long summers and the resultant above average use of air conditioners and other household utilities.

The relatively larger proportion of total consumption expenditures allocated to purchases of food and beverages in Florida is not so easily attributable to a probable cause, although relatively lower average incomes in Florida may lead to a higher proportion of the total budget being expended for this commodity.

Validation of the Series

Since the present estimates of total personal consumption expenditures in Florida are the only ones available, direct evaluation of the validity of the estimated data series is not possible. Only indirect checks of its accuracy are feasible. The series was examined for stability across time, in terms of both the percentages of total consumption allocated to the different commodity groups and the implied average propensity to consume. Comparisons were also made between Florida and the United States with respect to the latter figure, and a similar contrast was drawn in terms of average propensity to consume out of disposable income only. The percentage of total U.S. consumption from a given product group accounted for by Florida consumers was also examined. In none of these cases are there discrepancies between the implications of the constructed series and a priori expectations.

In spite of a number of simplifying assumptions employed in derivation of the estimates, the 11 category personal expenditure series thus appears to be of reasonable accuracy. The most serious limitations of the series stem from the data base on which it is constructed. The reliability of the retail sales data in general is not entirely satisfactory, although considerable improvements have been made during recent years. In addition, as discussed earlier, the accuracy of the derived PCE series depends on the correction of the sales data for intermediate goods and for tourist expenditures. It is inevitable that these estimates have introduced a certain amount of error into the series. Another potential source of difficulty is the result of the indirect estimation of the several components of consumption not covered by the retail sales tax statutes.

The most critical indirect test of the validity of the estimates involves the analysis of their implications for consumer behavior. Such an examination is carried out in the following chapters of this study. The empirical results there reported provide considerable support for the probable accuracy of the series, since they are quite reasonable in terms of other information available about the state, as well as in terms of the results of previous investigations in the theory of consumer behavior.

Other Data Employed in the Study

Price Data

An independent set of price indices is not available for Florida. The nearest geographical area for which such indices are available for the period of the present analysis is the metropolitan region of Atlanta. Such a series is probably not a very good proxy for price movements in Florida, as it is to be expected that prices in an urban area would reflect a number of special factors of lesser or negligible importance for a broader, more diversified economy such as a state or region. In particular, one would expect urban prices of housing, housing services and transportation to be considerably above those of rural areas, while prices of other items might also tend to be slightly higher. The basket of goods appropriate to an urban setting is also quite different from that which would be important in a rural environment. For example, one would expect a relatively larger proportion of total expenditure to be accounted for by formal clothing in the city, as urban work requirements often involve more formal dress than is usual in non-metropolitan areas. Similarly, more would probably be spent for commercially-prepared food and beverages, due to restaurants and fast-food outlets. On the other hand, more would presumably be spent on blue jeans and outdoor gear in a rural setting.

The quarterly price series used in the present analysis of consumer demand in Florida are those available for corresponding commodity groups in the United States as a whole from the Data Resources Incorporated (DRI) data file. These series have been estimated on the basis of annual indices for groups of commodities that are published by the U. S. Department of Commerce [69]. While these indices are apparently superior to available alternatives, the use of national price indices in the analysis of state budget data does involve a number of problems, as local prices of certain types of goods will in general demonstrate some divergences from their national counterparts. In addition, the basket of goods appropriate for price indices in Florida is not likely to be identical to that used in the calculation of the national series.

The problem posed by the use of less-than-ideal price indices for the analysis of consumer demand in Florida is essentially one of errors in variables. The national index used as a proxy for local prices for a particular commodity group may be viewed as the local index plus a disturbance term. The use of this unsatisfactory substitute as an explanatory variable in the model will in general result in a downward bias of coefficients associated with it, and least squares estimators will be inconsistent [30, p. 283].[1]

In the special case where the national index is a satisfactory instrumental variable for the local index, the results of least squares regression will be consistent, although they will tend to underestimate the true values of the coefficients for small sample sizes, such as the present example. The problem is reduced to some extent by the use of a maximum likelihood estimation technique for the static model of the following chapter, as such a technique will result in consistent estimators, although prediction with such estimators will still be biased [30, pp. 283-291]. The problem will continue to be of potential importance in the partially dynamic model of Chapter IV, as a least squares technique has been used to estimate the parameters of that model.

Income Data

For purposes of the present study, income has been taken to be the sum of consumption expenditures for all commodity groups. The portion of income devoted to saving has not been explicitly considered. In essence, within the context of the utility tree introduced by Strotz [61], the study examines only the allocation among commodity groups of the portion of total income devoted to the consumption "branch." The savings versus consumption decision, i.e., the choice of total amount to be allocated to the consumption branch, is not analyzed here. Such a procedure is quite legitimate, under the utility tree assumption, and in fact is required if we are to be able to constrain the sum of all marginal budget shares to unity (see Chapter III), as has been the usual practice in most previous studies where the choice between savings and consumption was not the focus of the analysis.

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[1] To the extent that systematic differences can be shown to exist between price movements in Florida and in the United States for particular commodity groups, the disturbance term introduced by use of the national rather than state price indices will no longer be random, and the unambiguous downward bias of coefficients that is implied by the errors in variables model will not be the case. Rather, in this instance, it may be possible to specify more exactly the amount and direction of the bias, thereby permitting improved estimates of the true parameters of the model.

The use of total consumption expenditure rather than total income will increase the value of estimated marginal budget shares over what they would be if savings were explicitly incorporated. The value of estimated elasticities will also be affected, as elasticity estimates for the reduced model will be larger than they would have been for the more complete system (as long as savings is not large relative to the amount of income devoted to consumption). In any case, comparability with most previous studies is obtained by consideration of the reduced model utilized in the following chapters.

CHAPTER III
A STATIC MODEL OF CONSUMER DEMAND IN FLORIDA

This chapter briefly discusses the advantages and limitations of a number of utility functions that have been used in previous studies of consumer behavior. The demand equations associated with one of these functions are derived and used in conjunction with the data base described in the previous chapter to obtain estimates of the parameters of consumer behavior in Florida. Corresponding estimates are made for the entire United States, and a comparison is drawn between results for the two regions.

General Theoretical Restrictions

Analysis of consumer behavior proceeds from the selection of a set of demand equations satisfying the general restrictions implied by the theory of consumer behavior. These restrictions are: (1) homogeneity of degree zero in income and prices; (2) satisfaction of the budget constraint over the relevant range of variation in prices and income; (3) negativity of the own-price substitution effect; and (4) symmetry of the matrix of substitution effects across all goods.

These general conditions do not refer explicitly to the utility function itself. In fact, the choice of a utility function is relatively unrestricted since the constrained maximization process itself guarantees satisfaction of these conditions by demand equations derived from any quasi-concave utility function [4, p.7]. The selection of a utility function for empirical purposes therefore is limited mainly by the specific restrictions implied by the associated demand equations.

Common Basic Assumptions

In any study of consumer behavior it is impossible to consider explicitly all commodities that are exchanged in the market place. Assumptions about the utility function are thus common in all such analyses. If the structure of consumer preferences is assumed to exhibit separability, then individual commodities may be grouped and the problem reduced to manageable size. Other common simplifying assumptions are that the utility function exhibits additivity or is linear in its variables or in some transformation of them. The implications of these assumptions for the analytical validity of a model are examined below.

The assumption of separability permits the aggregation of individual commodities into groups that may be considered as units, thus enabling comprehensive analysis of consumer behavior. Two types of separability have been defined. Weak separability, which is sufficient for most theoretical purposes, has been shown by Leontief [34] to be implied if the marginal rate of substitution between two variables belonging to any one group is not affected by variables from any other group. The definition of strong separability is similar, with the difference that the marginal rate of substitution between members of two different groups is unaffected by the variables in any other group. This assumption is much less desirable than that of weak separability, since it implies groupwise independence, and hence cardinality of the utility function expressed in terms of groups, although not necessarily in terms of individual commodities [4, p.5].

A weakly separable utility function may be portrayed as a "utility tree," to use the terminology introduced by Strotz [61]. The consumer budget is first allocated among the broad commodity groups that represent the branches of the tree. The budget allotment for each branch is then subdivided among the commodities in that branch, without further consideration of the allocation of resources within other branches. In theory, this allocation process could include many more than just two stages, since commodity groups in each branch might be defined as new sub-branches within which the allocation process continues. The assumed existence of such a utility tree effectively reduces the number of variables that must appear in any given demand equation. In formulating the demand equation for a good in a certain branch of the utility tree, all prices of goods not in that branch may be ignored. This does not imply that the demand for a commodity is independent of purchases outside its own branch, but rather it is assumed that all of this information was included in the initial determination of the budget allotment to the branch in question. The inclusion of the branch allotment as an argument in the demand equation therefore makes explicit consideration of outside prices redundant and unnecessary.

Strong separability has all of the implications of weak separability. In addition, it permits the combination without aggregation bias of any number of groups to form larger, more comprehensive groups. This is not generally true of weak separability, where the structure of the utility tree plays a more important role. Formally, strong separability implies groupwise independence, which can be shown to be the same as additivity between groups. In the extreme case where each group is composed of a single commodity, this of course reduces to total additivity.

The assumption of additivity allows for the possible independence of demands for certain goods. A function is defined as an additive preference ordering if it is a monotonic transformation of a function that is additive in its arguments. The most important implication of additivity is that the marginal rate of substitution between any two goods does not depend on the level of consumption of any other good [6, p. 1166].

Other empirical implications of additivity depend on whether it is the direct or the indirect utility function that is affected [27]. Additivity of the direct utility function implies proportionality of the cross-price derivatives and the income derivatives of the demand functions. In other words, the response of demand for a given commodity to a change in the price of another commodity is proportional to the response induced by a change in income. Additivity of the indirect utility function implies that the cross-price derivatives of the demand functions are proportional to the actual quantities demanded. This in turn requires that the cross-price elasticities with respect to any one given price all must be equal, and that they are functions of only that price. If both the direct and the indirect utility functions exhibit additivity, all elasticities with respect to total expenditure are equal and therefore unitary [4, p. 36]. All Engel curves are thus straight lines through the origin, and a constant proportion of income will be spent on each commodity at all income levels. This result precludes the existence of inferior or superior goods. Additivity, as defined above, unfortunately has a cardinal property, and although there have been several attempts to redefine additivity in ordinal terms, such efforts have met with only minor success [46, p.60].

The assumption of linearity is often useful in applied work. All of the results of direct additivity apply to functions exhibiting linearity. In addition, all goods are substitutes according to the Hicksian definitions.[1] It is also difficult to allow for inferior goods within the linear model, as such goods would have a negative sign in the utility function, implying that the rational consumer would not buy any even if the price were very low.

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[1] According to the Hicksian criteria, goods will be substitutes whenever the cross substitution effect is positive, while a negative or zero value of the cross substitution effect will imply complementarity or independence, respectively. In general, the cross substitution effect may be expressed as:

$$k_{ij} = \frac{\partial x_j}{\partial p_j} + x_j \cdot \frac{\partial x_j}{\partial Y}$$

In the case of direct additivity, this expression reduces the general condition [46, p.63]

$$k_{ij} = \frac{-\partial x_i}{\partial Y} \cdot \left(x_j + \frac{\lambda}{\partial \lambda / \partial Y} \cdot \frac{\partial x_j}{\partial Y}\right) + x_j \frac{\partial x_i}{\partial Y}$$

$$= -\frac{\lambda}{\partial \lambda / \partial Y} \cdot \frac{\partial x_j}{\partial Y} \cdot \frac{\partial x_i}{\partial Y}$$

where λ is the Lagrange multiplier used to incorporate the budget constraint. Since the derivatives of x_i and x_j with respect to income will in general be positive and λ, which may be interpreted as the marginal utility of income, is also positive, the entire expression will be positive only if $\partial \lambda / \partial Y$ is negative. But since an ordinary and usual assumption is that the marginal utility of income is decreasing, this will normally be the case, and k_{ij} will thus be positive, the condition required for Hicksian substitutability.

The implications of the above described assumptions within various empirical frameworks are examined further in the following sections.

The Linear Expenditure System

The linear expenditure system was originally introduced by Klein and Rubin [31] in their attempt to develop a constant-utility cost of living index. It was later formulated by Stone [58] into a system of demand equations satisfying all general restrictions. The utility function from which the system may be derived was developed by Samuelson [55] and by Geary [18], and Samuelson [55] has suggested an intuitive economic interpretation. The Stone-Geary utility function, as this function is now known, is specified as follows:

$$u = \Sigma_i \beta_i \log\ (x_i - \gamma_i) \tag{7}$$

where β_i and γ_i are parameters characterizing the function, which is denominated in terms of quantities of commodity x_i, and where γ_i may be interpreted as a minimum requirement for the good i. Utility is accordingly obtained from purchases over and above these minimum acceptable quantities. The function is defined for all $(x_i - \gamma_i) > 0$, subject to the constraint from economic theory that $x_i > 0$. Further, because all marginal utilities must be positive, each β_i must also be greater than zero, since,

$$MUx_i = \frac{\partial u}{\partial x_i} = \frac{\beta_i}{x_i - \gamma_i} > 0$$

First order conditions for a maximum of statement (7) subject to the budget constraint that $\Sigma_i p_i x_i = Y$, give the result that,

$$\lambda p_i = \frac{\beta_i}{x_i - \gamma_i} \quad \text{or} \quad \lambda(p_i x_i - p_i \gamma_i) = \beta_i \quad i=1.....n.$$

where λ is the Lagrange multiplier used to impose the budget constraint. No loss of generality is incurred by imposing the normalization rule that $\Sigma_i \beta_i = 1$, which permits solution for the value of λ as:

$$\lambda = (y - \Sigma_j p_j \gamma_j)^{-1}$$

Substitution for this value for λ leads to a system of demand equations of the form:

$$x_i = \gamma_i + \frac{\beta_i}{p_i} (y - \Sigma_j p_j \gamma_j) \qquad (8)$$

which is equivalent to:

$$p_i x_i = p_i \gamma_i + \beta_i (y - \Sigma_j p_j \gamma_j) \qquad (9)$$

The set of equations described by statement (9) has been termed the linear expenditure system. It states that expenditures for a given good i are composed of two portions. One part, $p_i \gamma_i$, may be interpreted as the minimum expenditure on good i that is required for subsistence. The quantity $(y - \Sigma_j p_j \gamma_j)$ may then be interpreted as the supernumerary income over which the consumer exercises discretion in his budgeting decisions. From statement (7) above, it is purchases from this income that are arguments in the utility function. Note also that statement (9) expresses a relationship between expenditure and income, and with constant prices, is thus an equation for a linear Engel curve.

The linear demand equations associated with the Stone-Geary utility function imply that all goods are Hicksian substitutes and that inferior goods do not exist. All the results of direct additivity apply as well. In particular, the cross-price derivatives are proportional to the income derivatives of the demand functions, and the marginal rate of substitution between any two goods does not depend on the level of consumption of other goods. In addition, it may be observed from statement (8) that if $\gamma_i > 0$, the own-price elasticity of demand for good i is less than unity. Conversely, if $\gamma_i < 0$, own-price elasticity of demand is greater than one.[1] As noted above, the Stone-Geary utility function yields linear Engel curves, though fortunately these are not required to pass through the origin as with simultaneous direct and indirect additivity.

An interesting measure of welfare has been developed from the income elasticity of the Lagrange multiplier, λ, that is utilized in the maximization of the Stone-Geary function. It follows from the first order conditions for a constrained maximum of statement (7) that $\lambda = 1/(y - \Sigma_i p_i \gamma_i)$. The income elasticity of λ is thus: $\omega = -y/(y - \Sigma_i p_i \gamma_i)$. The absolute value of ω

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[1] The effect of the sign of γ_i on the own-price elasticity of demand for good i can be seen through the following derivation, which is based on statement (8).

$$\varepsilon_{ii} = \frac{-\partial x_i}{\partial p_i} \cdot \frac{p_i}{x_i} = \frac{\beta_i p_i^{-1}(y - \Sigma_j p_j \gamma_j)}{\gamma_i + \beta_i p_i^{-1}(y - \Sigma_j p_j \gamma_j)}$$

If $\gamma_i > 0$, the denominator of this ratio will clearly be larger than the numerator, and ε_{ii}, the own-price elasticity of demand for good i, will be less than unity. Similarly, if γ_i is less than zero, the good will have an own-price elasticity of demand greater than one, since the denominator of the ratio will now be less than the numerator by a commensurate amount.

is then the ratio of total income to supernumerary income, and will vary inversely with the relative size of supernumerary income. This ratio has been termed by Frisch [15] as "money flexibility," and may be interpreted as a welfare measure. The idea is that since utility in the linear expenditure system is derived from supernumerary income, the larger the relative size of such income, the better off the consumer will be. Therefore, the smaller the absolute value of ω, the greater the welfare of the consumer.

A wide variety of empirical studies have been conducted using the linear expenditure system since its original presentation by Stone [58]. The consumption patterns of nearly every developed country of the Western world have been studied in the context of this model, along with those of numerous other nations. The system continues to be popular for empirical applications of the theory of consumer behavior, and several efforts have been made to generalize its premises. The function has been specified to allow for price sensitivity of the γ's and β's. Brown and Heien [7] have generalized the system to permit weak rather than strong sparability. Finally, the model has been reformulated as a dynamic system. Some of this work will be explored in this study.

The Quadratic Utility Function

The quadratic utility function is another common framework for analysis. It may be specified as follows:

$$u = \Sigma_i a_i x_i + (1/2)\ \Sigma_i \Sigma_j a_{ij} x_i x_j$$

or in matrix notation,

$$u = a'x + (1/2)\ x'Ax$$

where x and a are column vectors and A is a symmetric matrix of constants.

The principal advantage of the quadratic utility function is that the associated first order conditions are linear. The function is also reasonably flexible. Random shocks to the system, for example, may be introduced as simple alterations of the vector a. The function may be made additive by requiring that all off-diagonal elements of the matrix A be zero. The constraint of decreasing marginal utilities for any given commodity is fulfilled by requiring that the diagonal elements be negative, and it is relatively easy to impose either weak or strong separability on the system. The function may also be generalized to form part of the same class as the Stone-Geary function, and linear demand curves may be derived [46, p.70, p.109].

Unfortunately, there are several problems with the quadratic utility function that offset these advantages, including the lack of an intuitively plausible explanation for the specific mathematical formulation of the model, except as a second order Taylor approximation to an arbitrary utility function. Another difficulty is that empirical applications of the quadratic utility function have not been entirely satisfactory. The additive form of this function, which is most common in applied work, was utilized with apparently good results by Houthakker and Taylor [28] in their detailed study of U.S. consumer behavior. There is, however, an unexplained sharp decrease in the marginal utility of income at the end of their estimating period, and the estimation technique was initially thought to contain some flaw [28, p. 230]. Further investigation has revealed that the problem was a defect of the quadratic utility function itself [62]. The function has also been inferior in terms of forecasting performance. For empirical purposes, the linear expenditure system is better in almost every respect.

The Addilog Utility Functions

The derivation of the addilog (for "additive logarithmic") utility functions is due to Houthakker [27]. The origin of his work was an attempt to derive the double logarithmic demand function, which has the advantage of an excellent statistical fit, from a utility function satisfying the general restrictions of demand theory. The addilog utility function may be specified in either direct or indirect terms. Consider the indirect addilog utility function,

$$u = \Sigma_i a_i \; (y/p_i)^{b_i} \tag{10}$$

By constrained maximization, this function yields the set of demand equations:

$$x_i = \frac{a_i b_i Y^{b_i} p_i^{-b_i - 1}}{\Sigma_j a_j b_j Y^{b_j - 1} p_j^{-b_j}} \qquad i = 1 \ldots n.$$

The ratio of two such equations eliminates the nonlinear denominator of the above expression, as:

$$\frac{X_i}{X_j} = \frac{a_i b_i Y^{b_i} p_i^{-b_i - 1}}{a_j b_j Y^{b_j} p_j^{-b_j - 1}}$$

Multiplying through by one in the form of (Y/Y), and transforming into logarithmic form, this becomes:

$$\log x_i - \log x_j = \log a_i b_i - \log a_j b_j + (1 + b_i) \log (Y/p_i) \\ - (1 + b_j) \log (Y/p_j).$$

From this expression, estimating equations can be obtained which yield estimates of the parameters b_i and b_j. The relevant income and price elasticities implied by the original indirect utility function of statement (10) above can then be calculated. The derivation of demand equations for the direct addilog utility function:

$$u = \Sigma_i \alpha_i x_i^{\beta i}$$

proceeds in a similar fashion and is not presented here (see [6]).

The most obvious implications of the addilog functions are those of direct or indirect additivity. For the indirect addilog function, the cross-price elasticities with respect to any given price are equal across all commodities, and are functions only of that price. For the direct addilog function, the cross-price derivatives of the demand functions for any two commodities are proportional to the income derivatives. In either case, the marginal utility of an increase in consumption of any good is independent of the level of consumption of any other good. The model has substantial flexibility in some respects. Complementary goods and a limited number of inferior goods can be introduced fairly easily, and the income response may be formulated to permit a considerable range of Engel curves (see [6]). On balance, though, the addilog models are probably just as restrictive as the linear expenditure system, although the restrictions affect different responses.

One serious drawback of addilog functions is their relatively poor empirical performance as compared to other specifications of the utility function; Theil found that the average information inaccuracy of the addilog model was considerably larger than either the linear expenditure system or his Rotterdam model, although it did perform somewhat better for predictive purposes than the linear system [66, pp. 243-7]. Other authors have also generally found the linear system to be superior to the addilog models [6, pp. 1203-4], and the greater intuitive plausibility of the former is certainly an important advantage.

Homothetic Utility Functions

A utility function is homothetic if it is a monotonic transformation of any (linearly) homogeneous function. The Bergson family of utility functions [5] constitutes the special subgroup of this general category that also demonstrates additivity. Homotheticity of the utility function implies demand equations that are homogeneous of degree -1 in prices. It further implies that all commodities have constant unitary income elasticities [6, p. 1167]. With constant relative prices, such a result would mean that the same proportion of total expenditure would be allocated to each commodity at all levels of income. This would preclude the existence of inferior or superior goods. This implication is somewhat less limiting in a model where other (e.g., time and/or social) constraints are imposed, since the constant proportion result can hold in this case without necessarily implying that non-normal goods do not exist. The model remains very restrictive even so and for this reason, homothetic utility functions are generally not used in empirical analysis. The Bergson subgroup is even more limited by the further restriction of additivity.

The Rotterdam Model

In the foregoing models, a utility function is specified and demand equations are derived through a process of constrained maximization. The optimization process itself guarantees that the general restrictions of demand theory will be satisfied. Alternatively, one could specify appropriate demand equations and impose the general restrictions as constraints during the maximization process. This procedure apparently avoids the loss of generality implied by the choice of a given utility function, although a particular set of demand equations may implicitly involve restrictions that are characteristic of certain classes of utility functions.

Theil ([64], [66]) has followed this procedure in the derivation of the Rotterdam system, which has been the basis for a large amount of theoretical and empirical work, including most notably the contributions of Barten ([2], [3]). The Rotterdam system is based on the decomposition of demand changes into responses to movements of real income and to price changes, as:

$$dx_i = \frac{\partial x_i}{\partial y} (dy - \Sigma_h x_h dp_h) + \Sigma_j s_{ij} dp_j$$

where s_{ij} is the substitution effect on the ith commodity of a change in the jth price, and where the quantity in parentheses represents net change in income after allowing for possible price movements. Since in general, $dz = zd\log z$, the above expression can be restated as:

$$x_i d\log x_i = \frac{\partial x_i}{\partial y} (yd\log y - \Sigma_h x_h p_h \; d\log p_h) + \Sigma_j s_{ij} p_j d\log p_j .$$

Multiplying through by (p_i/y), one obtains:

$$w_i d\log x_i = B_i \; (d\log y - \Sigma_h w_h d\log p_h) + \Sigma_j C_{ij} d\log p_j \qquad (11)$$

where $w_i = (p_i x_i/y)$, the proportion of total expenditure allocated to x_i; $B_i = p_i \; \frac{(\partial x_j)}{\partial y}$; and $C_{ij} = (p_i p_j s_{ij}/y)$. If B_i and C_{ij} are assumed to be fixed, a finite approximation of equation (11) may be estimated directly.

In empirical work a commonly used approximation is

$$w_i d\log x_i = B_i d\log\bar{y} + \Sigma_j C_{ij} d\log p \qquad (12)$$

where $d\log\bar{y} = \Sigma w_i d\log x_i \simeq (d\log y - \Sigma_h w_h d\log p_h)$, and $\bar{y}$ is real rather than nominal income [6, p. 1189].

In principle, the system described by statement (12) can be estimated, and each constraint of conventional demand theory can be applied in turn and tested for validity.[1] The more constraints that may validly be imposed, the greater the precision of the estimates and the closer the model conforms to the theory of consumer demand. Thus the model itself may be tested indirectly by its conformity to the theoretical restrictions, a test that is generally not possible for most other types of models. Another advantage is that with correct choice of parameters, the model can be shown to include as special cases variants of both the linear expenditure system and the direct addilog demand equations [11, p. 343], thus providing a framework for direct comparability of these two functional forms.

Unfortunately, the Rotterdam model may be shown to imply a homothetic utility function of the Bergson type [19]. Such functions imply constant budget shares at all levels of income, a feature that robs the Rotterdam model of most empirical interest. Although the model may still be justified as the first term of a Taylor approximation to an arbitrary demand function (e.g., as in [3]), it appears to be inferior to more general models, such as the linear expenditure system.

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[1] The constraints of conventional demand theory may be stated as:

$\Sigma_i B_i = 1$, the adding-up condition;

$\Sigma_j C_{ij} = 0$, the homogeneity condition;

$C_{ij} = C_{ji}$, symmetry of substitution effects; and

$C_{ii} < 0$, negativity of own substitution effects.

Additivity may also be imposed on the system by the further constraint, $C = \phi(\hat{B} - BB')$ where $\hat{B}$ is a diagonal matrix with elements of the vector B along the diagonal.

The Translog Utility Functions

Another model which has been suggested as a framework within which to test the validity of general theoretical restrictions is the translog (for "transcendental logarithmic") utility function, in either its direct or indirect formulation [10]. The derivation of these models is based on utilization of a monotonic transformation to express the (direct) utility function in logarithmic form, as

$$\ell n\ U = \ell n\ U\ (X_1,\ X_2,\ \ldots,\ X_n)$$

Maximization of this expression, subject to the budget constraint, $\Sigma_i p_i X_i = Y$, gives the set of equilibrium conditions,

$$\frac{\partial \ell n\ U}{\partial \ell n\ X_j} = \frac{p_j X_j}{Y} \cdot \Sigma_i \frac{\partial \ell n\ U}{\partial \ell n\ X_i} \qquad j = 1,\ \ldots,\ n \qquad (13)$$

The negative of the logarithm of the utility function may be approximated by a quadratic function of the quantities consumed, as

$$-\ \ell n\ U = \alpha_o + \Sigma_i \alpha_i\ \ell n\ X_i + 1/2\ \Sigma_i \Sigma_j \beta_{ij}\ \ell n\ X_i \ell n\ X_j \qquad (14)$$

Substituting (14) into (13), and performing indicated operations results in the set of equations:

$$\alpha_j + \Sigma_i \beta_{ij}\ \ell n\ X_i = \frac{p_j X_j}{Y} \cdot \Sigma_i\ (\alpha_i + \Sigma_k\ \beta_{ik}\ \ell n\ X_k) \qquad j = 1,\ \ldots,\ n.$$

Setting $\Sigma_i\alpha_i = \alpha_M$, and $\Sigma_i\beta_{ik} = \beta_{Mk}$, this expression may be rewritten with the budget share p_jX_j/Y as the dependent variable, so that

$$\frac{p_jX_j}{Y} = \frac{\alpha_j + \Sigma_i\beta_{ij}\ \ell n\ X_i}{\alpha_M + \Sigma_k\beta_{Mk}\ell n\ X_k} \qquad j = 1,..., \tag{15}$$

The budget constraint implies that only (n-1) of these expressions are independent; the nth is fully determined by the parameters of any (n-1) equations of the model. Finally, since the equations (15) are homogeneous of degree zero in the parameters, a normalization is required for estimation. A convenient normalization is to set $\Sigma\alpha_i = \alpha_M = -1$. Equations for the budget shares implied by the indirect translog utility function are derived in an analogous manner (except that the positive logarithm of the utility function is approximated by the quadratic expression), and are not presented here.

The theory of demand implies that all β_{Mk} appearing in the j equations (15) must be the same, if the equations are generated by utility maximization. It also implies that the parameters β_{ij} are symmetric, so that $\beta_{ij} = \beta_{ji}$ for all $i \neq j$. Christensen, Jorgenson, and Lau [10], the originators of this approach, used a likelihood ratio test to examine the validity of these restrictions. They also formulated a number of tests of restrictions implied by different mathematical forms of the utility function, based on conditional acceptance of the validity of the theory of demand. Results of their tests indicated that the restrictions imposed by the theory of demand could be rejected at the .01 level of significance; they therefore concluded that the theory of demand was inconsistent with the evidence. Their tests of functional form, assuming the theory of demand to be valid, indicated that the hypothesis of homotheticity could be rejected for both the direct and indirect series of tests, while that of additivity could be rejected for the direct series of tests, but not for the indirect series. In sum, the authors conclude that the theory of demand, along with many mathematical models often utilized in related empirical studies, is not consistent with the statistical evidence.

Although the results of the test of demand theory facilitated by the translog function are of considerable interest, they do not provide a definitive refutation of the theory. For one thing, the tests used may be biased toward rejection of the null hypothesis, as they are based on the asymptotic distribution of the t-statistic without correction for small sample size [4, p.51]. In addition, as pointed out by Barten [4, p.34], the unsatisfactory performance of constraints on a macro level does not provide irrefutable evidence against a theory that is based on individual behavior. So many possibly invalid assumptions are incorporated in the maintained hypotheses on the macro level that it may be possible to demonstrate that the constraints in this context are too restrictive on the data without invalidating the underlying theoretical premises.

One possible defect of the translog functions for empirical work is the lack of an intuitively plausible interpretation of their specific mathematical form. In addition, the functions were introduced quite recently and have not yet been utilized to much extent in the analysis of consumer behavior; comparability with previous work is thus more limited than with more widely used models. Finally, the approach also presents several estimation problems not affecting other formulations. For these reasons, the translog models have not been employed in this study.

Other Functional Forms

Several other mathematical formulations of the utility function have been attempted in applied work on consumer demand. Most of these models have been employed only on a limited basis, and therefore they were not utilized in the present study.

One such set of models, originated by Leser [35], is sometimes referred to as the "Australian" model. It is based on the statement of expenditures for a particular commodity as a linear function of income and prices. The constraints of demand theory are then imposed, along with constraints on the relationship between elasticities of substitution for the different goods. Powell and associates [53] have employed such a model in their study of consumer demand in the post-war period, but with the further constraint of additivity. It has been argued that the formulation presents greater sensitivity to prices than is the case with most models of consumer demand. The problem with the Australian models is that satisfaction of the theoretical constraints will occur in general only for values equal to the means of the observations [6, p.1207]. The model may not be at all satisfactory for all values within the range of experience.

Another type of functional form, sometimes referred to as the "generalized Leontief" model, has recently been presented by Diewert [12]. Using the concept of duality of expenditure and utility functions, Diewert notes that the consumer's expenditure function may be expressed as:

$$E(U_o, p) = \Sigma_i \Sigma_j b_{ij} \, p_i^{1/2} \, p_j^{1/2} \, U_o \tag{16}$$

which is a generalized version of the Leontief expenditure function from which the approach takes its name. The b_{ij} in equation (16) are defined as parameters such that $b_{ij} = b_{ji}$, and are generally expected to be positive. If some b_{ij} are less than zero, the expenditure function may not assume a desirable (i.e., concave) shape over the entire range of prices. Since optimal expenditure will be exactly equal to income, the dual of the expenditure function (16) defines the consumer's indirect utility function, which in this case will be,

$$V = Y/(\Sigma_i \Sigma_j \; b_{ij} \; p_i^{1/2} \; p_j^{1/2})$$

The system of market demand equations is then derived as the ratio,

$$X_i = \frac{\Sigma_j \; b_{ij} \; p_i^{-1/2} \; p_j^{1/2} \; Y}{\Sigma_k \; \Sigma_m \; b_{km} \; p_k^{1/2} \; p_m^{1/2}} \qquad i = 1, \ldots, n. \qquad (17)$$

Diewert has used the model of statement (17) to analyze the inter-relationships between aggregate consumption, savings, labor supply, and money demand, but it has not yet been employed in other contexts, and thus is of only limited interest for purposes of the present study.

Choice of Model Structure

After evaluation of the various models discussed above, the linear expenditure system was selected as the theoretical basis of this study, principally due to the plausibility of its economic interpretation. Consumers probably do have a minimum requirement for purchases from each group of commodities, especially if the group is a broad aggregate, as a result of social and physical constraints not explicitly incorporated into the model. The assumption that utility is obtained from purchases over and above this amount causes no loss of generality.

The fact that the system is derived by constrained maximization implies that all of the general theoretical restrictions on the demand equations are fulfilled. Additional specific restrictions are fewer than those of several possible alternatives. In addition, the linear system has withstood the test of empirical application much better than other models. The extensive work with the linear expenditure system on the national level is also attractive, since it facilitates the investigation of potential differences in the structure of consumer preferences and responses in Florida as compared to the United States as a whole, a principal goal of the present study.

Estimating Equations

If it is assumed that expenditures on commodity i are affected by a spherical disturbance term, ε_i, equation (9) may be restated as:

$$p_i x_i = p_i \gamma_i + \beta_i (Y - \Sigma_j p_j \gamma_j) + \varepsilon_i \qquad i = 1, \ldots, n.$$

Since this equation is equivalent to,

$$p_i x_i = \beta_i Y + (1 - \beta_i) \gamma_i p_i - \beta_i \sum_{i \neq j} \gamma_j p_j + \varepsilon_i \tag{18}$$

the system may be estimated as a set of regressions of expenditures for different commodities on income and on all prices. Application of ordinary least equares to each of the equations separately will not give optimal estimates, since the budget constraint implies that the sum of the disturbances across equations must be identically zero, and thus these terms must be correlated across the entire system of equations (as $\Sigma\varepsilon_i = 0$). In addition, in order that β_i may be interpreted as a marginal budget share, the system should be estimated subject to the normalization restriction that $\Sigma\beta_i = 1$. Finally, the nonlinearity of the coefficients of equation (18) requires special estimation techniques. An iterative maximum likelihood technique developed by Richard W. Parks [44] for the linear expenditure system has been used to estimate the present model. Empirical results are reported below.

The procedure of Parks is based on a Gauss-Newton method of search for the maximum of the likelihood function. Such methods are essentially founded on a Taylor series expansion around an initially supplied set of parameter values [20, Chapter I]. If the initial values are relatively close to those corresponding to the true maximum of the function, convergence is generally fairly rapid [65]. On the other hand, if the values are sufficiently far from the optimal set so that the function is no longer concave in the relevant range, these methods may not converge and may tend to move in the wrong direction. For this reason, it is usually good practice to begin from several different arbitrary starting points, both in order to insure convergence and to guarantee a global rather than a local maximum. This problem is reduced somewhat in a model such as the one presently under consideration, where the initial values of one set of parameters (the β_i's) are limited for theoretical reasons to a relatively small range (i.e., $0 < \beta_i < 1$). It remains a possibility, however, as the β_i's could still not converge within the permissible range, and in any case, the γ_i's are unrestricted.

Parks has incorporated his method into a computational algorithm known by the acronym of MAXLES. This program was used to estimate the static version of the linear expenditure system presented in equation (18) above. The data used were quarterly observations on per capita expenditures and prices for Florida for the period from 1968-III through 1973-IV, a total of 22 observations in all.[1] These data and their derivation were described in detail in Chapter II. Because of a limitation on the number of commodity groups that may be analyzed in the framework of the MAXLES algorithm, four of the original commodity groups (other durables, other nondurables, other services, undistributed) were combined into a single category labeled "other" for purposes of estimation, thereby reducing the original 12 categories to 9.

The empirical results of the analysis are presented in Table 3. Standard errors are in parentheses beneath the estimated parameters. The β_i may be interpreted as marginal budget shares, since they sum to unity and are the coefficients of supernumerary income in expenditure equation (18) above. For the most part, the parameter estimates of Table 3 are consistent with such an interpretation, although the highest β_i is for the miscellaneous category, a result that is indicative of the large number of commodities that have been excluded from explicit incorporation in the present study, due to the lack of a sufficiently detailed statistical base. The remaining parameters are generally as expected on theoretical grounds. The second highest β_i is associated with automobiles and parts, while the lowest is for clothing and shoes. Both of these results are broadly consistent with a priori expectations, as are the relatively low β_i's

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[1] It is possible that serial correlation may be a problem with these data. The MAXLES algorithm makes no adjustment for this possibility. If serial correlation is indeed present, this will result in less efficient, although still unbiased, estimates of the parameters of the model. Parks [43] has discussed this possibility elsewhere, and has proposed a generalized least squares estimation technique incorporating appropriate adjustments.

Table 3. Florida: Static Version of the Linear Expenditure System, July 1968-December 1973

Commodity Group	β_i	γ_i
1. Automobiles and parts	0.1567 (0.0095)	-1.710 (5.477)
2. Furniture and household equipment	0.0685 (0.0062)	6.293 (3.939)
3. Food and beverages	0.1435 (0.0156)	88.597 (8.843)
4. Clothing and shoes	0.0149 (0.0043)	12.502 (1.637)
5. Gasoline and oil	0.0249 (0.0079)	19.940 (3.417)
6. Housing	0.0309 (0.0089)	17.969 (2.072)
7. Housing operation	0.0892 (0.0093)	20.863 (5.660)
8. Transportation	0.0530 (0.0047)	-6.097 (1.952)
9. Other	0.4184 (0.0144)	42.954 (17.235)

associated with gasoline and oil, housing, and transportation. One possible anomaly lies in the high estimated value of the marginal budget share of food and beverages. The traditional role of foodstuffs as a basic necessity item would seem to indicate a much lower value of this parameter, although the inclusion of restaurant food and alcoholic beverages may mean that this category includes a substantial amount of discretionary spending. Such an explanation would be consistent with the relatively large amount of total expenditure devoted to this category (see Chapter II).

The parameter γ_i has been interpreted as a minimum subsistence amount of commodity i that would be purchased by the consumer even if his current income were to be completely eliminated. Such an explanation, although it does not allow for negative values of γ_i, is broadly consistent with the values in Table 3. The highest γ_i is associated with the food and beverages group, while estimates for the durable goods categories (automobiles and parts, furniture and household equipment) are quite low.

The parameters of the estimating equations (18) may be used to derive estimates of the income and price elasticities of consumer demand in Florida. The demand equation implied in (18) is expressed as:

$$x_i = \frac{\beta_i}{p_i} Y + (1 - \beta_i)\gamma_i - \frac{\beta_i}{p_i} \sum_{i \neq j} \gamma_j p_j \quad i=1,\ldots,n \tag{19}$$

Since the income elasticity of demand for a given commodity is by definition:

$$\eta_i = \frac{\partial x_i}{\partial Y} \cdot \frac{Y}{x_i}$$

It may be expressed in the present case:

$$\eta_i = \frac{\beta_i}{p_i} \cdot \frac{Y}{x_i} = \beta_i \cdot \frac{Y}{p_i X_i} \tag{20}$$

which is also equal to the income elasticity of expenditure on commodity i, derived from equation (18) as,

$$\frac{\partial p_i x_i}{\partial Y} \cdot \frac{Y}{p_i x_i} = \beta_i \cdot \frac{Y}{p_i x_i}$$

Similarly, the cross-price elasticity of demand for commodity i with respect to changes in the jth price is defined in general as:

$$\varepsilon_{ij} = \frac{\partial X_i}{\partial p_j} \cdot \frac{p_j}{x_i}$$

which, if applied to equation (19), gives the result that:

$$\varepsilon_{ij} = \frac{-\beta_i \gamma_j}{p_i} \cdot \frac{p_j}{x_i} = -\beta_i \gamma_j \cdot \frac{p_j}{p_i x_i} \tag{21}$$

This is also equal to the cross-price elasticity of expenditure on commodity i, derived from equation (18) as:

$$\frac{\partial p_i x_i}{\partial p_j} \cdot \frac{p_j}{p_i x_i} = -\beta_i \gamma_j \cdot \frac{p_j}{p_i x_i}$$

Finally, the own-price elasticity of demand for a given commodity i is expressed by definition as:

$$\varepsilon_{ii} = \frac{\partial x_i}{\partial p_i} \cdot \frac{p_i}{x_i}$$

which, applied to equation (19), leads to

$$\varepsilon_{ii} = \frac{-\beta_i \left(Y - \sum_{i \neq j} p_j \gamma_j\right)}{p_i x_i}$$

Unlike the previous cases, own-price elasticity of demand is not exactly identical to its counterpart with respect to expenditure. It is closely related, however, since the own-price elasticity of expenditure on commodity i may be derived from equation (18) as:

$$\frac{\partial p_i x_i}{\partial p_i} \cdot \frac{p_i}{p_i x_i} = \frac{(1 - \beta_i)\, p_i \gamma_i}{p_i x_i}$$

The own-price elasticity of demand for the ith commodity may be derived directly from this expression for the own-price elasticity of expenditure, since the difference between the two is equal to one.[1] This may be demonstrated as:

$$\frac{\partial p_i x_i}{\partial p_i} \cdot \frac{p_i}{p_i x_i} - \varepsilon_{ii} = \frac{(1 - \beta_i)\, p_i \gamma_i + \beta_i \left(Y - \sum_{i \neq j} p_j \gamma_j\right)}{p_i x_i}$$

$$= \frac{p_i \gamma_i + \beta_i \left(Y - \Sigma_j\, p_j \gamma_j\right)}{p_i x_i}$$

$$= \frac{p_i x_i}{p_i x_i} = 1$$

It therefore follows that the own-price elasticity of demand for the ith commodity may be expressed in terms of parameters derived from the estimating equation (18) as:

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[1] This is true only for the expected values of the two elasticities, which are what is relevant for the present purposes. In general, for a single given observation, the difference will be equal to one plus a disturbance term.

$$\varepsilon_{ii} = \frac{\partial p_i x_i}{\partial p_i} \cdot \frac{p_i}{p_i x_i} - 1 = \frac{(1 - \beta_i)\gamma_i p_i}{p_i x_i} - 1 \qquad (22)$$

The price and income responses associated with the parameter estimates of Table 3 are presented below in Table 4. They are derived from the values in Table 3 according to the indications of statements (20), (21), and (22) above. All elasticities have been calculated at the mean values of prices and expenditures. Standard errors have been approximated by a Taylor's series expansion, and are presented below the parameters to which they correspond [32, p.444].

In order to provide a basis for evaluation of the results, corresponding estimates were made for the United States as a whole. The data used were those presented by the Department of Commerce in the Survey of Current Business. The period of the analysis was again taken as the quarters from 1968-III through 1973-IV, and the exercise was carried out with respect to the nine major categories of expenditure that were utilized in the analysis of Florida consumption patterns. The resulting parameter estimates are presented in Table 5. Standard errors are presented in parentheses below the estimate to which they correspond. The price and income elasticities associated with these estimates of β_i and γ_i for the United States are presented in Table 6, along with approximate standard errors. The U.S. parameters and elasticities were calculated in the same manner as the Florida estimates presented previously. All elasticities were evaluated at the mean values of prices and expenditures.

Empirical Results

The parameter estimates presented above for Florida and the United States appear to be quite reasonable, as do the associated elasticity

Table 4. Florida: Static Income and Price Elasticities, July 1968-December 1973

Category	η_i	ϵ_{ij}								
		1	2	3	4	5	6	7	8	9
1. Automobiles and parts	1.5767 (0.0954)	-1.0209 (0.0670)	-0.0142 (0.0095)	-0.2447 (0.0357)	-0.0359 (0.0058)	-0.0501 (0.0099)	-0.0482 (0.0077)	-0.0552 (0.0175)	0.0191 (0.0061)	-0.1265 (0.0564)
2. Furniture, household equipment	1.2786 (0.1163)	0.0032 (0.0100)	-0.8436 (0.0985)	-0.1985 (0.0488)	-0.0291 (0.0045)	-0.0406 (0.0089)	-0.0391 (0.0067)	-0.0448 (0.0134)	0.0155 (0.0048)	-0.1026 (0.0432)
3. Food and beverages	0.5779 (0.0630)	0.0014 (0.0046)	-0.0052 (0.0026)	-0.4646 (0.0464)	-0.0132 (0.0025)	-0.0184 (0.0038)	-0.0177 (0.0029)	-0.0202 (0.0057)	0.0070 (0.0024)	-0.0464 (0.0191)
4. Clothing and shoes	0.4582 (0.1316)	0.0011 (0.0036)	-0.0041 (0.0027)	-0.0711 (0.0226)	-0.3101 (0.0931)	-0.0146 (0.0036)	-0.0140 (0.0043)	-0.0161 (0.0068)	0.0056 (0.0024)	-0.0368 (0.0175)
5. Gasoline and oil	0.5192 (0.1640)	0.0013 (0.0042)	-0.0047 (0.0034)	-0.0806 (0.0265)	-0.0118 (0.0032)	-0.3539 (0.1156)	-0.0159 (0.0051)	-0.0182 (0.0077)	0.0063 (0.0029)	-0.0416 (0.0209)
6. Housing	0.6099 (0.0776)	0.0015 (0.0048)	-0.0055 (0.0036)	-0.0947 (0.0159)	-0.0139 (0.0025)	-0.0194 (0.0038)	-0.4151 (0.0650)	-0.0214 (0.0050)	0.0074 (0.0025)	-0.0489 (0.0199)
7. Housing operation	0.9590 (0.0999)	0.0024 (0.0076)	-0.0086 (0.0053)	-0.1489 (0.0202)	-0.0218 (0.0041)	-0.0305 (0.0064)	-0.0293 (0.0029)	-0.6569 (0.0095)	0.0116 (0.0042)	-0.0769 (0.0309)
8. Transportation	2.3721 (0.2106)	0.0058 (0.0188)	-0.0213 (0.0142)	-0.3682 (0.0563)	-0.0540 (0.0092)	-0.0754 (0.0158)	-0.0725 (0.0122)	-0.0831 (0.0268)	-1.5135 (0.1641)	-0.1903 (0.0844)
9. Other	1.1879 (0.0409)	0.0029 (0.0094)	-0.0107 (0.0134)	-0.1844 (0.0208)	-0.0271 (0.0036)	-0.0377 (0.0069)	-0.0363 (0.0043)	-0.0416 (0.0114)	0.0144 (0.0046)	-0.8675 (0.0546)

Table 5. United States: Static Version of the Linear Expenditure System, July 1968-December 1973

Commodity Group	β_i	γ_i
1. Automobiles and parts	0.1263 (0.0143)	-13.295 (8.614)
2. Furniture and household equipment	0.1045 (0.0032)	-5.121 (2.865)
3. Food and beverages	0.0658 (0.0093)	97.051 (4.112)
4. Clothing and shoes	0.1025 (0.0038)	9.036 (2.891)
5. Gasoline and oil	0.0334 (0.0020)	8.130 (0.774)
6. Housing	0.1608 (0.0067)	21.990 (2.288)
7. Housing operation	0.0697 (0.0025)	6.694 (1.476)
8. Transportation	0.0276 (0.0016)	5.584 (0.352)
9. Other	0.3095 (0.0109)	50.956 (6.534)

Table 6. United States: Static Income and Price Elasticities, July 1968-December 1973

Category	η_i	ε_{ij}								
		1	2	3	4	5	6	7	8	9
1. Automobiles and parts	1.8245 (0.2070)	-1.2273 (0.0770)	0.0126 (0.0076)	-0.2916 (0.0359)	-0.0282 (0.0081)	-0.0222 (0.0039)	-0.0642 (0.0105)	-0.0193 (0.0047)	-0.0190 (0.0023)	-0.1632 (0.0308)
2. Furniture, household equipment	1.5981 (0.0489)	0.0288 (0.0187)	-1.0942 (0.0525)	-0.2554 (0.0132)	-0.0247 (0.0078)	-0.0195 (0.0018)	-0.0562 (0.0064)	-0.0169 (0.0039)	-0.0167 (0.0012)	-0.1429 (0.0192)
3. Food and beverages	0.3205 (0.0451)	0.0058 (0.0037)	0.0022 (0.0013)	-0.2729 (0.0378)	-0.0050 (0.0017)	-0.0039 (0.0007)	-0.0113 (0.0024)	-0.0034 (0.0009)	-0.0033 (0.0006)	-0.0287 (0.0058)
4. Clothing and shoes	1.1863 (0.0434)	0.0214 (0.0143)	0.0082 (0.0048)	-0.1896 (0.0089)	-0.8393 (0.0520)	-0.0144 (0.0014)	-0.0417 (0.0048)	-0.0125 (0.0028)	-0.0124 (0.0010)	-0.1061 (0.0134)
5. Gasoline and oil	0.9465 (0.0560)	0.0170 (0.0104)	0.0065 (0.0035)	-0.1513 (0.0125)	-0.0146 (0.0052)	-0.6664 (0.0322)	-0.0333 (0.0042)	-0.0100 (0.0024)	-0.0099 (0.0009)	-0.0847 (0.0126)
6. Housing	1.0981 (0.0460)	0.0198 (0.0123)	0.0076 (0.0040)	-0.1755 (0.0135)	-0.0170 (0.0060)	-0.0134 (0.0014)	-0.7985 (0.0216)	-0.0116 (0.0028)	-0.0115 (0.0007)	-0.0982 (0.0142)
7. Housing operation	1.1849 (0.0417)	0.0213 (0.0135)	0.0082 (0.0044)	-0.1894 (0.0115)	-0.0183 (0.0062)	-0.0144 (0.0014)	-0.0417 (0.0043)	-0.8329 (0.0371)	-0.0124 (0.0009)	-0.1060 (0.0135)
8. Transportation	0.9352 (0.0528)	0.0168 (0.0105)	0.0064 (0.0034)	-0.1494 (0.0124)	-0.0145 (0.0053)	-0.0114 (0.0014)	-0.0329 (0.0041)	-0.0099 (0.0025)	-0.6564 (0.0220)	-0.0836 (0.0143)
9. Other	1.0193 (0.0358)	0.0184 (0.0115)	0.0070 (0.0039)	-0.1629 (0.0102)	-0.0158 (0.0052)	-0.0124 (0.0011)	-0.0358 (0.0033)	-0.0108 (0.0023)	-0.0106 (0.0008)	-0.7966 (0.0413)

estimates. In addition, the precision of the estimates, as evidenced by the magnitude of standard errors relative to corresponding coefficients, is in general fairly good. There are a few discrepancies between corresponding parameters for the two different regions, however, as well as some differences from previous studies with respect to the elasticity associated with particular classes of commodities.[1] The estimates for each of the separate commodity categories are discussed below. To facilitate comparison of the two regions, income and own-price elasticity results for Florida and the United States are summarized in Table 7.

Automobiles and parts. The marginal propensity to spend for automobiles and parts is higher than that of most other categories in the case of both Florida and the United States, although the estimate for Florida is somewhat higher in absolute terms. The minimum subsistence quantity is negative for both regions, although not significantly different from zero. The income elasticity of demand is large relative to other goods and is of similar magnitude for both regions, about 1.6 for Florida and about 1.8 for the United States. Expenditure in both regions is associated with an elastic own-price response. The pattern of cross-price elasticities is also similar for the two regions, with very little apparent effect of changes in automobile prices on purchases of other commodities; most such estimates are in fact smaller than their associated standard errors. In addition, with the exception of food prices, changes in prices of other

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[1] The β_i and γ_i parameters and income and own-price elasticities for Florida were compared statistically with those for the United States through a likelihood ratio test. All parameters demonstrated significant differences at the 99 per cent level of confidence. Although these pairwise results are of course not conclusive, as a complete series of tests should examine each pair of coefficients in light of demonstrated differences appearing between all other pairs, it nonetheless does provide some supporting evidence for the following discussion.

Table 7. Florida and the United States: Static Income and Own-Price Elasticities, July 1968-December 1973

Commodity Group	Income Elasticity		Own-Price Elasticity	
	Florida	United States	Florida	United States
1. Automobile parts	1.5767	1.8245	-1.0209	-1.2273
2. Furniture, household equipment	1.2786	1.5981	-0.8436	-1.0942
3. Food and beverages	0.5779	0.3205	-0.4646	-0.2729
4. Clothing and shoes	0.4582	1.1863	-0.3101	-0.8393
5. Gasoline and oil	0.5192	0.9465	-0.3539	-0.6664
6. Housing	0.6099	1.0981	-0.4151	-0.7985
7. Housing operation	0.9590	1.1849	-0.6569	-0.8329
8. Transportation	2.3721	0.9352	-1.5135	-0.6564
9. Other	1.1879	1.0193	-0.8675	-0.7966

Sources: Tables 4 and 6.

goods also seem to have a neglible (although generally significantly different from zero) impact on purchases of automobiles and parts.

Although the estimated income elasticity of demand is larger for automobiles and parts than for any other commodity, it is considerably below the corresponding estimate obtained by Houthakker and Taylor [28] in their study of consumer demand in the United States. They estimated income elasticities of demand for automobiles and parts of between 5.0 and 6.3, about three to four times the present estimates. Chow ([8], [9]), on the other hand, found evidence of income elasticities ranging from 1.5 to 2.0, about the same as those obtained in the present study. Similarly, although the own-price elasticities associated with this category in the present study are larger than those of other commodity groups, they are lower than the estimates of between -1.5 and -1.9 obtained by Houthakker and Taylor, and slightly above the estimates of Chow, which ranged between -0.6 and -1.1.

Furniture and household equipment. Empirical results for this second category of durable goods are broadly similar for the United States and Florida. Marginal budget shares are in the intermediate range, although somewhat lower in absolute terms for Florida than for the United States as a whole. Minimum subsistence quantities in both regions are close to zero. Income elasticities are also similar, although the estimate for the United States is slightly higher than for Florida, just as was the case with respect to automobiles. Own-price response is slightly elastic for the United States, and of just less than unitary elasticity for Florida. All cross-price elasticities are quite small for both regions, again with the exception of responses to movements in food prices, and changes in prices of other goods generally have a larger impact (usually statistically significant) on furniture purchases than the corresponding effect in the opposite direction.

Previous investigations have obtained income elasticity estimates that are considerably higher than those of the present study. Houthakker and Taylor [28] have estimated that the income elasticity of demand for furniture in the United States is about 2.2 - 2.4. On the other hand, the own-price elasticity estimates of the present study are approximately the same as those reported by these authors.

Food and beverages. The estimated marginal budget share of food and beverages for Florida is more than double that for the United States, and estimated income and own-price elasticities of demand demonstrate nearly the same degree of difference. The pattern of cross-price elasticities is approximately the same for both regions, however, with changes in food prices having a relatively large impact on other purchases, but with price movements for other items having only a small effect on expenditures for food.

The apparently much greater degree of responsiveness of food purchases in Florida to changes in incomes and food prices is difficult to explain, especially in view of the relatively larger amount of the total budget allocated to such purchases in Florida. One possible explanation stems from the large part of the sample period encompassed by the years 1970-71, during which time there was an economic slowdown in the nation as a whole that had very little impact on Florida. Thus, the elasticity estimates for food purchases in the United States during this period may be lower than usual, while those for Florida are more nearly at a normal level.

Such an interpretation is substantiated by comparison of the empirical results of the present study with those of previous analyses. The income elasticity estimates for the United States obtained by previous investigators are for the most part considerably higher than those of the present study. Houthakker and Taylor [28] found an income elasticity of demand for food and beverages of about 0.7. A similar estimate, 0.64, was obtained by Hassan et al. [25]. In addition, Houthakker and Taylor found a higher own-price elasticity response (-0.47), similar to that obtained for Florida in the present study, while the other cited study found evidence of a lower elasticity (about -0.3) that is closer to the results for the United States obtained in the present investigation. Neither of these two studies is inconsistent with the notion that the discrepancy in the present analysis between estimates for the United States and for Florida may be due to purely temporary phenomena, and may not reflect a basic structural difference between the pattern of consumption response in the two regions.

It is also possible that the larger income and own-price elasticities of demand for food and beverages in Florida may be due to an incomplete correction of the expenditure data for the amount allocated to such goods by tourists. As tourist expenditures within this group tend to be concentrated on higher-priced purchases (mostly from restaurants), their incomplete exclusion would presumably cause an upward bias of the estimated responsiveness of demand to income and price changes. Thus, to the extent that the correction for tourist expenditures on food and beverages (described in Chapter II) is incomplete, the higher parameters estimated in this study are not indicative of basic structural differences between the two regions.

Clothing and shoes. There is a major difference between Florida and the United States in the empirical results with respect to clothing and shoes; the U.S. marginal budget share is nearly seven times as large as the corresponding Florida figure. Further, income and own-price elasticity estimates for Florida are much smaller than for the United States. The estimates of income elasticity of demand for goods in this category are 0.46 and 1.19 for Florida and the United States, respectively, while own-price elasticity estimates are -0.31 and -0.84. In addition, although cross-price elasticity estimates are broadly similar for the two regions, price changes for other goods appear to have somewhat less impact on clothing purchases in Florida than in the nation as a whole. In sum, less clothing is apparently purchased by Florida consumers than by the average American, and clothing purchases in Florida tend to be of a less discretionary nature.

Estimates from other studies for the United States as a whole tend to reinforce the above observation, as they are remarkably similar to those obtained for the United States in the present investigation. Houthakker and Taylor [28] and Hassan et al. [25] found evidence of income elasticities of demand for clothing and shoes that ranged from 1.1 to 1.25, almost exactly the same as the estimate for the United States obtained in the present study. Powell et al. [53] estimated an income elasticity that was only slightly less at 0.9. The evidence is similar with respect to own-price elasticity, with all the above-cited studies reporting estimates ranging from -0.44 to -0.62, somewhat less than the estimate of -0.84 of the present study, but still considerably above the corresponding figure of -0.31 obtained for Florida. The lower and apparently more inelastic nature of demand for clothing and shoes by Floridians is probably directly related to the moderate Florida climate and the large proportion of retired persons resident in the state.

Gasoline and oil. The estimated marginal budget shares allocated to gasoline and oil are similar for Florida and for the United States as a whole. The estimated responses of demand for gasoline and oil to price and income movements demonstrate some differences, as the responses for the entire United States are somewhat more elastic than those for Florida alone. There is also a closer relationship between gasoline prices and automobile purchases in Florida and in the United States as a whole; the same holds true for expenditure on other transportation services.

The above results are consistent with a priori expectations, since Floridians, as residents of a state with only limited energy resources, have much less choice about energy sources than residents of other parts of the country. In addition, the relatively larger amount of total expenditure devoted to automobiles and the limited availability of alternative means of transportation probably will also result in a relatively more rigid minimum requirement for gasoline. In such circumstances, it is to be expected that gasoline prices will have a comparatively greater effect on automobile purchases. The larger impact of gasoline prices on purchases of other transportation services may also stem from the small amount of rail and other mass transit forms within the state.

The empirical results of previous studies of demand for gasoline and oil are so varied that they do not provide a satisfactory basis for comparison. Estimates of the income elasticity of demand for gasoline and oil in selected studies of U.S. consumption patterns range from a low of 0.4 [28] to a high of 1.2 [26]. Own-price elasticity estimates present almost as much variation, but in general tend to be lower than those obtained for either region in this study. No definitive evaluation of the present results can therefore be made by comparison with previous estimates.

Housing. There is a marked difference between the state of Florida and the United States as a whole with respect to the marginal budget share of housing services. Responses to changes in prices and incomes also differ substantially. The estimated income elasticity for Florida is about 0.6, while that for the United States is approximately 1.1. Own-price elasticities show a similar difference, with the absolute value of the estimate for Florida slightly above 0.4, and the corresponding figure for the United States nearly double that amount.

The significance of the difference between the estimates for the two regions is enhanced by a comparison with results of previous empirical studies. Own-price elasticity estimates in such studies are broadly compatible with those estimated for the United States in the present analysis, and most have concluded that the income elasticity of demand for housing is unitary or elastic, a finding consistent with the results of the present investigation.[1] For example, Muth [38] found time-series evidence of an income elasticity of housing demand of approximately 1.0, while Reid [54] obtained estimates indicating a somewhat more elastic response. Although both these authors used the value of housing stocks as their dependent variable, it may be argued that their empirical results are applicable to analysis of the demand for housing services. Such will be the case if housing expenditures are approximated by a constant proportion of the value of housing stock, since in such circumstances, the resultant elasticities will be the same, i.e., if housing expenditure (x) = a . housing value (v), where a is a constant, then

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[1] This was not true of the short-run elasticity estimates of Houthakker and Taylor [28] and of Powell et al. [53], which were very close to zero. Their longer-run results indicated elasticities of approximately unity, however.

$$\eta_x = \frac{\partial(a \cdot v)}{\partial y} \cdot \frac{y}{a \cdot v} = \frac{a \cdot \partial v}{\partial y} \cdot \frac{y}{a \cdot v} = \frac{\partial v}{\partial y} \cdot \frac{y}{v}$$

On the other hand, if the relationship between housing value and expenditure for housing services is more nearly approximated by a linear function, all elasticities will tend to be biased. If the intercept is positive, as is most likely, the direction of the bias will be downward. Such a result could partially explain the low elasticity estimates found for Florida in the present study; it does not explain the apparent difference between the two regions with regard to this parameter, however.

The apparently more inelastic demand for housing in Florida and the smaller marginal budget share allocated to this category are probably due in part to the moderate Florida climate and to generally less elaborate construction methods. There is also a relatively larger number of mobile homes and other housing units that are cheaper per square foot of living space than housing commonly available in other parts of the country. As noted previously, Floridians on the whole devote a much larger proportion of total expenditure to mobile homes than the average U.S. resident.

Housing operation. There are only minor differences in the empirical results for Florida and the United States with respect to housing operation.

The marginal budget share for Florida is slightly higher and income and own-price elasticities are slightly lower than for the United States as a whole. The estimated income elasticities are remarkably close to those obtained in previous studies (e.g., [25], [28], [53]), and the price elasticities are approximately the same as the estimates of Powell et al. [53], although they are slightly above the results of other previous studies. In general, though, the results of the present analysis accord very closely with previous work, and provide no real basis for distinguishing between the response of consumers in Florida and those in the entire United States.

Transportation services. There are substantial differences betwen empirical estimates for the two regions with respect to expenditures for transportation services. The marginal budget share of such expenditures is considerably higher for Florida than for the United States. Further, a negative value is associated with the minimum subsistence quantity of such services in Florida, and both income and own-price elasticities are greater than one in absolute value. The estimated income elasticity of demand is nearly 2.4, while the corresponding estimate for the United States is just less than unity. Own-price elasticity of demand in Florida is also more than double the estimate of -0.66 obtained for the United States.

Previous studies again tend to corroborate the above results, as most such studies have obtained similar empirical results for the United States. An approximately unitary income elasticity of demand for transportation services was found by a number of authors ([25], [28], [53]), who also found that own-price elasticity of demand for such services was less than unity; in fact, their estimates are even below that obtained for the United States in the present study.

An explanation for the apparently greater elasticity of demand for transportation services in Florida is not immediately obvious. One possibility, although admittedly only a speculative one, is that the relatively undeveloped nature of most transportation services in Florida has resulted in an above-average concentration of such expenditures on services of a less basic nature such as air travel. If such a concentration were to be the case, the more elastic response would be consistent with expectations. No substantiating evidence is available, however.

It should also be noted in this case that empirical results such as those presented here would be likely to occur if the basic data series has not been completely corrected for tourist expenditures within this category. Such expenditures would be concentrated on more expensive modes of travel, such as air service, and would be likely to exhibit higher elasticities of demand, thus biasing upward the results of the analysis.

Other. No substantive difference is apparent between Florida and the United States in the empirical results for this category, although the marginal budget share for the United States is somewhat lower than that for Florida. The estimated income and price elasticities for the two regions are virtually identical.

Summary and Conclusions

This chapter has presented and analyzed a static model of consumer demand in the state of Florida. Several common types of demand functions employed in previous studies of the budget allocation process were surveyed and their advantages and disadvantages described. Of these, the linear expenditure system was chosen as the basic model for the present study, mainly due to the intuitive appeal of its economic interpretation and the extensive amount of previous work in which it has been utilized successfully. The model was applied to data developed on personal consumption expenditures within the state of Florida for the period from mid-1968 through the end of 1973. In addition, to provide a basis for evaluating the results, estimates were derived for the entire United States using comparable data for the same period.

Although the empirical results of the study are in the main fairly similar for the United States and Florida, there are substantive differences between the two regions with respect to the pattern of responses within certain commodity categories. In particular, there appear to be significant differences in the categories of food and beverages, clothing and shoes, housing and transportation services. A smaller amount of difference between the two regions is apparent with respect to automobiles and parts. Some of these discrepancies, as for example with respect to food and beverages, are probably due principally to the differential regional impact of national economic developments. Others (e.g., those affecting clothing and housing) are probably the result of the relative mildness of the Florida climate and the skewed age structure of the population. For the remaining categories (automobiles and transportation), no definitive explanation is possible on the basis of present information, but the relatively undeveloped nature of most public transportation in Florida may be a partial cause. In sum, the empirical results of the present study provide evidence of substantial variation between consumer behavior in Florida and in the nation as a whole. Most of these differences are to be expected on a priori grounds, due to particular characteristics of the state, such as climate, age structure of the population and so forth.

The existence of regional differences in the response of consumers to price and income stimuli, as demonstrated by the empirical results presented above, is potentially of great importance in the design and implementation of economic policies initiated on the state or local level. For example, an indication that Floridians are relatively sensitive to price and income stimuli in making decisions regarding the purchase of housing services would be of considerable interest to localities considering revision of their property tax laws, as property tax rates in such circumstances should presumably have a stronger impact on choice of locations by both present and potential residents. The fact that demand for transportation services is more elastic in Florida than in the rest of the country is an important consideration to be taken into account in the formation of pricing policy by local mass transit authorities. Lower elasticities of demand for clothing and shoes have implications for sales tax policy, as well as for prediction of the behavior of sales tax receipts from this sector. Differences between Florida and the United States with regard to the estimated marginal budget shares for different commodities should also be helpful in forecasting the future course of sales tax receipts and in evaluating the revenue impact of proposed changes in the sales tax laws. Other benefits of the additional information about consumer behavior in Florida made available by this study may also be catalogued.

In the following chapter, the differences that became evident through the analysis of the static model are tested for robustness through the application of a more sophisticated model to the basic data series. As will be noted, empirical results of application of the more elaborate (partially dynamic) model to the case of Florida, although not entirely satisfactory or conclusive, do tend to corroborate the results described above.

CHAPTER IV
A DYNAMIC MODEL OF CONSUMER DEMAND IN FLORIDA

The static model of the previous chapter is useful in that it describes the equilibrium quantities demanded for any combination of prices and income. In a world of instantaneous adjustment, such a model would be sufficient to describe completely the behavior of the consumer. Unfortunately, adjustment may often be far from instantaneous. Consumers tend to develop habits which reduce the short-run responsiveness of their pattern of commodity purchases to changes in prices and incomes. In addition, some goods are more durable than others, and may not depreciate in time to permit instantaneous adjustment to price and income movements. The consumer may also have fixed payment obligations that prevent immediate response to changes in the economic environment. Finally, the consumer may not become immediately aware of the new situation, and a learning process may be required before adjustment can occur. These and other rigidities in the economic structure of society limit the usefulness of static analysis of consumer behavior.

Most efforts to introduce dynamic behavior into the analysis of consumer demand have been based on the application of some form of distributed lag (see survey in [22]). The most common assumption has been a geometric lag distribution, which has the advantage of being described by a single parameter [33]. The partial adjustment model introduced by Nerlove [41] has also been employed extensively. One special case of this model was used by Chow [8] in his landmark study of consumer demand for automobiles. Further modifications have been applied to the study of consumer durables in general (e.g., [17], [24], [42], [60]). The difficulty with all of these models is that the specific mathematical form of the general utility function from which they derive has not yet been identified and it is thus very difficult to extend the approach to deal with an entire system of demand equations.

A Partially Dynamic Version of the Linear Expenditure System

The suggestion that dynamization of the linear expenditure system might be desirable was made as early as its first empirical application by Stone [58]. He suggested that such a modification could be achieved through the introduction of a time trend or through the incorporation of information about past purchases of the commodity in question. A wide variety of studies have utilized the first option, usually with reasonably goods results [66, vol. 1, p. 240]. Recently, attempts have been made to dynamize the system using the second approach. Pollak [50] specifies the minimum quantity γ_i's as linear functions of consumption of commodity i in previous periods, while Phlips [45] states the γ_i's as linear functions of state variables representing stocks (in the case of durables) or habits (for nondurables and services). This permits the introduction of depreciation rates, and allows short-term behavior to be depicted as partial adjustment to long-run equilibrium. Both authors were inspired by similar efforts by Houthakker and Taylor [28] to dynamize the quadratic utility function. The principal advantage of both models is that they are based on a modification of the consumer's utility function to reflect dynamic qualities, followed by derivation of corresponding demand equations. This procedure is much more general than many previous attempts to introduce dynamic factors into single commodity demand functions.

The Phlips Model

Phlips ([45], [46]) introduces dynamic factors into the model by specifying the minimum quantities γ_i as linear functions of state variables representing stocks or habits. The subsistence quantities γ_i of the static model are redefined as,

$$\gamma_i = \theta_i + \alpha_i s_i \tag{23}$$

where s_i is the relevant state variable corresponding to commodity i, and θ_i and α_i are constants. The parameter α_i should be positive for non-durables (where s_i may be interpreted as a habit) and negative for durables (where s_i may be interpreted as a stock). The utility function is now redefined as:

$$u = \sum_{i=1}^{n} \beta_i \log (\dot{x}_i - \theta_i - \alpha_i s_i) \tag{24}$$

The dynamic input into the model consists of assumptions about the behavior over time of the state variables s_i. Phlips assumes that s_i declines at a fixed exponential rate of depreciation, δ_i, so that the behavior of s_i over time may be expressed as:

$$\frac{ds_i}{dt} = \dot{s}_i = \dot{x}_i - \delta_i s_i \qquad i = 1, \ldots, n \tag{25}$$

The change in the magnitude of the state variable s_i during time period t is equal to new purchases of commodity i minus the relevant amount of depreciation of stocks (in the case of durable goods) or wearing off of habits (for nondurables and services).

First order conditions for a maximum of the modified utility function are analogous to those of the static model, as:

$$\lambda P_i = \beta_i/(x_i - \theta_i - \alpha_i s_i) \qquad i = 1,\ldots,n. \tag{26}$$

Substitution into the budget constraint, $\Sigma_i P_i X_i = y$, yields a value of the marginal utility of income λ as:

$$\lambda = \Sigma_i \beta_i/(y - \Sigma_i P_i \theta_i - \Sigma_i \alpha_i P_i s_i) \tag{27}$$

a function of income, all prices, and all state variables. Substituting (27) into (26) and simplifying gives the result that

$$P_i x_i = P_i(\theta_i + \alpha_i s_i) + \beta_i(y - \Sigma_j P_j \ (\theta_j + \alpha_j s_j))/\Sigma_i \beta_i \qquad i = 1,\ldots n. \tag{28}$$

This is a dynamic version of the linear expenditure system, where past consumption decisions now affect present budget allocation through their impact on the value of state variables representing habits or stocks of durable goods. As with the static model, individual β_i's must exceed zero in order that marginal utilities be decreasing, and the utility function is defined only for x_i exceeding the minimum quantities $\theta_i + \alpha_i s_i$. The depreciation rates δ_i from statement (25) should also be positive. A useful simplification is normalization of the β_i's to permit their interpretation as marginal budget shares.

Estimating Equations

The dynamic version of the linear expenditure system is not directly amenable to estimation in its present form for two reasons. First, it includes the unobservable variables s_i, and second, the set of restrictions described in statement (25) has not yet been incorporated. These problems may be resolved by substitution following a procedure outlined by Houthakker and Taylor [28, pp.10-12]. Unfortunately, the procedure results in a set of estimating equations that require the regression of current period expenditures within any commodity group on the past value of expenditures within that group, on both the current and past values of total expenditure, and on all prices, both for the current and for the past period. Such a procedure will be feasible only for models of very limited size, due to both the sheer weight of the computations and probable econometric difficulties associated with multicollinearity and loss of degrees of freedom from incorporation of not one but two prices for every commodity.

These difficulties in estimation are avoided in the Phlips approach, which is based on another technique used by Houthakker and Taylor [28, p.202]. In this method, values of the marginal utility of income, λ , are not obtained by substitution, but rather are estimated by iteration until these estimates imply satisfaction of the budget constraint. The calculated values of λ are then used to derive estimates of the remaining parameters in the model. The first order conditions of statement (26) serve as the basis for the derivation of estimating equations. The value of the quantities demanded implied by this statement is:

$$x_i = \Theta_i + \alpha_i s_i + \beta_i \pi_i \qquad i = 1,\dots,n \qquad (29)$$

where $\pi_i = 1/\lambda P_i$. The derivative of this expression with respect to time is:

$$\frac{dx_i}{dt} = \dot{x}_i = \alpha_i \dot{s}_i + \beta_i \dot{\pi}_i \qquad i = 1, \ldots n$$

A finite approximation in terms of first differences is:

$$x_{it} - x_{it-1} = \alpha(s_{it} - s_{it-1}) + \beta(\pi_{it} - \pi_{it-1}) \qquad i = 1, \ldots, n \qquad (30)$$

Winder [71] and Houthakker and Taylor [28] have demonstrated that a more accurate finite approximation is obtained if the state variables are expressed at average values, rather than at end-of-period values, i.e., if the variables s_{it} are replaced by the average of the beginning and end values, or $(s_{it} + s_{it-1})/2$. This means that statement (25), which describes the movement of the state variables over time, can be rewritten as:

$$\dot{s}_{it} \cong (s_{it} + s_{it-1})/2 - (s_{it-1} + s_{it-2})/2$$

or $$2\dot{s}_{it} \cong s_{it} - s_{it-1} + s_{it-1} - s_{it-2} \cong \dot{s}_{it} + \dot{s}_{it-1}$$

which, when combined with the right hand side of statement (25), leads to:

$$2\dot{s}_{it} \cong x_{it} - \delta_i s_{it} + x_{it-1} - \delta_i s_{it-1} = x_{it} + x_{it-1} - \delta_i (s_{it} + s_{it-1})$$

Substituting this result into equation (30) gives:

$$2(x_{it} - x_{it-1}) = \alpha_i (x_{it} + x_{it-1}) - \alpha_i \delta_i (s_{it} + s_{it-1}) + 2\beta_i \cdot (\pi_{it} - \pi_{it-1})$$

Replacing $\alpha_i s_i$ by its value implied in statement (29), collecting terms, and simplifying this equation may be rewritten without the unobservable state variables as:

$$x_{it} = (2 - \alpha_i + \delta_i)^{-1}((2 + \alpha_i - \delta_i)\, x_{it-1} + 2\delta_i\theta_i + (\delta_i + 2)\, \beta_i\pi_{it} + (\delta_i - 2)\, \beta_i\pi_{it-1})$$

In other words, the estimating equations may be expressed as:

$$x_{it} = K_{i0} + K_{i1}x_{it-1} + K_{i2}\,(\lambda_t P_{it})^{-1} + K_{i3}(\lambda_{t-1}P_{it-1})^{-1} \qquad (31)$$

where the structural parameters of the model are combinations of the regression coefficients as follows:

$$\alpha_i = \frac{4(K_{i1}K_{i2} + K_{i3})}{(1 + K_{i1})\,(K_{i2} - K_{i3})} \qquad \delta_i = \frac{2(K_{i2} + K_{i3})}{K_{i2} - K_{i3}}$$

$$\beta_i = \frac{(K_{i2} - K_{i3})}{(1 + K_{i1})} \qquad \theta_i = \frac{K_{i0}\,(K_{i2} - K_{i3})}{(1 + K_{i1})\,(K_{i2} + K_{i3})} \qquad (32)$$

The formulation of the model summarized by equation (31) reduces the number of variables to manageable proportions. Unfortunately, information about cross-price responses is no longer available directly from the empirical results. Rather, this information is now only implicit in the model through the definition of λ , which is derived through application of the budget constraint as:

$$\lambda_t = \Sigma K_{i2}/(Y_t - \Sigma P_{it}K_{i0} - \Sigma P_{it}K_{i1}x_{it-1} - (1/\lambda_{t-1})(\Sigma K_{i3}P_{it}/P_{it-1})) \qquad (33)$$

Estimation Procedure

Equation (31) may be specified stochastically for purposes of estimation through the introduction of a disturbance term, ε_t. A natural point for the introduction of such a disturbance, suggested by Pollak and Wales [51, p.616], is in the determination of the minimum required quantities γ_i. Accordingly, statement (23) is modified by the addition of a random spherical component, v_i, so that

$$\gamma_i = \theta_i + \alpha_i s_i + v_i$$

The result of inclusion of the stochastic element v_i is the addition to demand equation (31) of a disturbance term ε_{it} that is a linear combination of the v_i's,

$$\varepsilon_{it} = (2 - \alpha_i + \delta_i)^{-1} \left[(\delta_i + 2)v_{it} + (\delta_i - 2)v_{it-1}\right] \qquad (34)$$

The ε_{it}, as linear combinations of the multivariate normal v_t, will also have a multivariate normal distribution. While heteroskedasticity does not appear to be a problem with ε_{it} (unless v_i is heteroskedastic), it is obvious from statement (34) that autocorrelation will be present.

Another difficulty in estimation of the system of equations (31) is the need for an estimate of λ_t, the marginal utility of income. In the method suggested by Houthakker and Taylor [28, p.202], an arbitrary set of initial values is chosen for λ_t, and used to provide a set of regressors for the equations (31). The system is then estimated by an appropriate technique, and the resulting parameters are substituted in equation (33) to compute a new set of λ_t's. For this purpose, it suffices to hold the initial $\lambda_o = 1$ for all iterations. This implies a linear transformation of the utility function, but does not affect the validity of the results. The new λ_t's are then used to estimate a new set of parameters, and the process continues until the budget constraint is satisfied.

A further difficulty concerns the appropriate estimation technique to be applied at each iteration of the method. Clearly, single equation techniques are not satisfactory, since the disturbance terms associated with the system (31) are related across equations. The generalized least squares technique originally suggested by Phlips [45] is therefore not sufficient, even though it allows for the autocorrelation of errors within a single equation. Substantial improvement is therefore provided by the later Phlips suggestion [46] that the method proposed by Zellner [72] for seemingly unrelated regressions be used at every stage, as this technique explicitly considers the correlation of disturbance terms across equations. This technique has accordingly been used to estimate the partially dynamic model.

A number of problems are involved with the choice of this estimation technique. Since statement (31) is nonlinear in terms of the structural coefficients, the maximum likelihood estimation method employed with the static model of the previous chapter should ideally be nested in every iteration of the procedure. Unfortunately, the MAXLES package as written was not compatible with computer facilities available at the time of estimation of the partially dynamic model, and so has not been used. A further difficulty results from ignoring in the estimation procedure the likely autocorrelation evident from statement (34). Neglect of this influence will not bias the estimated coefficients, but will cause them to be subject to large variances. A generalized least squares procedure has been developed by Parks [43] to deal with problems such as this, and some improvement in the efficiency of the estimation method would probably have resulted from utilization of this technique. Finally, the Zellner procedure does not facilitate imposition of the normalization constraint, $\Sigma_i \beta_i = 1$, and these parameters may no longer be interpreted as marginal budget shares in this formulation of the model. Nevertheless, in spite of these difficulties, the technique as employed does parallel its application by Phlips [46], and should provide estimates comparable to those he reports. The specific procedure followed in application of the technique to the present problem is reported below.

The iterative application of the Zellner generalized least squares (GLS) procedure for seemingly unrelated regressions is relatively straightforward [30, pp. 238-40]. An estimate of the disturbance covariance matrix is obtained from the correlation among residuals of separate ordinary least squares regressions for the nine commodity groups. The nine equations are then grouped and the disturbance matrix is used to obtain GLS estimates of all (36) coefficients. After the Zellner estimates have been derived, they are substituted in the set of equations (31) to calculate estimated expenditures for each of the nine commodities. These are summed to provide the total expenditure implied by the parameter estimates. This estimate of total expenditure is then compared with known actual total expenditure to determine whether or not the budget constraint has been satisfied. The test used in the present application was a simple sign test, which essentially requires that positive and negative differences between individual pairs of observations be roughly equivalent in number. If the test is not satisfied, the parameter estimates are used to calculate a new set of λ's, according to the formula in statement (33). Price data are transformed by the new estimates of λ_t, and the entire process is repeated with the resulting new set of variables.

The sign test of equality of two data series is not a particularly powerful test, and it was discovered in estimation of the model that a considerable reduction in the mean difference between the actual and estiated series was achieved by further iterations after the test was first satisfied. The mean and variance of the vector of differences were substantially reduced, while the sign test criteria continued to indicate equality of the two series. Iterations were therefore continued until no further reduction in mean difference was obtained.[1] The final mean difference between the two series was -0.006. The largest single difference was -12.08, in the first quarter of 1973; this discrepancy was -1.3 per cent of the true level of total expenditure in that period.

The final set of estimated coefficients of the group of equations (31) is presented in Table 8. Standard errors are in parentheses below the estimates to which they correspond.

Comparison of the coefficients with associated standard errors reveals a considerable lack of precision with regard to certain estimates. The categories of clothing and shoes, gasoline and oil, and housing, all exhibit especially large variances. Only the groups of automobiles and parts, housing operation, and other unclassified consistently have estimated

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[1] In fact, both the mean and variance of the differences increased progressively in subsequent iterations.

Table 8. Florida: Estimated Regression Coefficients for Partially Dynamic Model
July 1968-December 1973

Commodity Group	K_{i0}	K_{i1}	K_{i2}	K_{i3}
1. Automobiles and parts	31.297 (6.056)	0.280 (0.159)	193.165 (33.702)	-181.310 (33.871)
2. Furniture, household equipment	14.121 (4.826)	-0.155 (0.190)	83.457 (26.766)	-59.227 (32.138)
3. Food and beverages	146.373 (15.422)	-0.141 (0.131)	410.287 (52.439)	-399.775 (55.143)
4. Clothing and shoes	9.356 (3.809)	-0.079 (0.217)	-11.377 (11.226)	23.079 (12.859)
5. Gasoline and oil	29.150 (5.717)	-0.261 (0.167)	31.382 (20.432)	-23.217 (22.271)
6. Housing	3.277 (1.996)	0.897 (0.064)	-1.990 (5.800)	2.128 (6.427)
7. Housing operation	28.032 (5.165)	0.699 (0.097)	101.092 (23.001)	-115.107 (27.066)
8. Transportation	3.598 (2.173)	0.320 (0.171)	41.550 (11.855)	-37.140 (12.539)
9. Other	89.852 (11.877)	0.322 (0.120)	419.093 (53.534)	-381.859 (54.128)

coefficients that are large relative to their standard errors. Indeed, this general lack of precision in the estimates appears to have had some negative implications for the validity of the empirical results of the model.

The structural coefficients implied by the regression results presented above may be derived algebraically by reference to statements (32) above. The results for the partially dynamic model applied to Florida are presented in Table 9. Standard errors have been approximated by a Taylor series expansion [32, p. 444], and are presented in parentheses below the coefficients to which they correspond.

There is a general lack of precision in most of the estimated regression coefficients of the dynamic model. Due to the interdependency of the equations of the model, this imprecision has adverse implications for all structural parameters. The poor results are undoubtedly linked to the large standard errors of some of the original regression coefficients, as well as to the high covariances between several of these parameters. One possible reason for this imprecision is the lack of correction in the present procedure for the likely autocorrelation of disturbance terms that was signaled by statement (34). Such autocorrelation would be expected to result in reduced precision of the estimated coefficients. It is possible that insufficient or inappropriate constraints were imposed on the model used to derive empirical estimates. The sum of the β_i's, for example, could be constrained to unity, as in the estimation of the static model. This additional constraint would have complicated the estimation process considerably, but may have resulted in more acceptable empirical results. It is also possible that certain constraints on the

Table 9. Florida: Structural Coefficients of Partially
Dynamic Model
July 1968-December 1973

	α_i	β_i	δ_i	θ_i
1. Automobiles and parts	-1.0620	292.5881	0.0633	772.4801
	(0.4154)	(66.4129)	(0.1838)	(2,251.1274)
2. Furniture, household equipment	-2.3950	168.8915	0.3396	98.4276
	(1.1060)	(73.2108)	(0.4628)	(166.2475)
3. Food and beverages	-2.6289	942.6797	0.0260	13,125.8072
	(0.7183)	(199.3621)	(0.1343)	(95,356.8263)
4. Clothing and shoes	-3.0216	-37.4055	-0.6792	-29.9080
	(1.3315)	(23.1422)	(0.7614)	(35.7837)
5. Gasoline and oil	-3.1109	73.8454	0.2991	263.6361
	(1.4652)	(53.3108)	(0.8356)	(746.4770)
6. Housing	-0.1759	-2.1712	-0.0668	-51.7061
	(2.9788)	(5.5536)	(2.9760)	(2,305.8957)
7. Housing operation	-0.4835	127.2249	-0.1296	-254.4654
	(0.2612)	(26.3911)	(0.2325)	(473.5663)
8. Transportation	-0.9175	59.5988	0.1121	48.6278
	(0.4910)	(12.7902)	(0.3199)	(145.6743)
9. Other	-0.9338	606.0845	0.0930	1,462.5858
	(0.2919)	(98.0921)	(0.1394)	(2,192.3875)

model (e.g., constancy of the depreciation rates, δ_i) may have been too rigid for the sample period under consideration, which was characterized by considerable economic change, some of which may have affected the structural responses implied by the dynamic model. Alternative estimation techniques also might have improved the final set of coefficients. As mentioned previously, an iterative maximum likelihood technique, such as that used to estimate the static model, should probably be imposed at each stage of the estimation process, rather than the generalized least squares approach used here.

Certain of the empirical estimates are quite surprising. All the estimated α_i's are negative, for example, which implies that purchases of any commodity i during a given time period will depress purchases of the item during subsequent periods. Such a result is entirely consistent for purchases of durable goods, which will last sufficiently long to reduce requirements for new items during following periods. The consistency of a negative α_i for nondurable goods, which last no more than a single period, is not so obvious. Interpretation of the state variables s_i as habits in this instance would imply that if anything, the parameter α_i should be positive for nondurables, reflecting a positive impact on subsequent purchases of the commodity in question. There are a number of possible explanations for the negatively signed results, however.

In the first place, it is possible that the consistently negative α_i's obtained in this study may stem from the data series used to test the model. Since the present analysis is based on quarterly observations, many goods that are ordinarily considered to be nondurables (e.g., clothing and shoes) will clearly last longer than a single period, and thus should be expected to exhibit some of the behavioral characteristics of durables. In addition, the commodity groups used in the present analysis are quite broad, and include a wide variety of nonhomogeneous goods. Thus, while habits may be formed with respect to particular individual commodities, it is quite conceivable that an entire group of commodities might not be subject to habit formation. Finally, as shown in Table 9, a number of the α_i's are not particularly large in relation to their approximated standard errors. This lack of precision may also be a partial cause for the uniformly negative α_i's.

Several other estimated coefficients have signs that appear to be highly unlikely, if not inadmissible on a priori grounds. A negative β_i, for example, such as that associated with clothing and shoes and with housing, implies inferiority of the associated commodity group, a very improbable result in view of the aggregated nature of both these categories. In this instance, however, since neither parameter differs significantly from zero, the results may actually lend additional support to the empirical findings reported earlier, since a low value for both would be consistent with the estimates obtained for the static model described in the previous chapter. A negative estimated depreciation parameter, δ_i, is also obtained for these two groups, as well as for the housing operation group. Such a result implies that appreciation of the state variable s_i will occur in every time period, even without new purchases of the associated commodity. Although appreciation may in fact occur for certain individual durable commodities that have time-related value, such as antiques, it is inconceivable for broad aggregates like those under consideration. In all three instances, however, the estimated coefficient is smaller than its standard error, and the negative result should accordingly not be given much weight.

An improved theoretical formulation of the model might lead to more reasonable empirical results. One limitation of this study is that it has examined only the allocation of a given level of total consumption expenditure, without regard to determination of the portion of total income devoted to consumption rather than to savings. In effect, the allocation of the consumer's budget has been viewed as a two-step process in which the consumer first allocates total income between savings and consumption, and then divides the amount allocated to consumption among the various commodities available to him. This study has examined only the second part of this process, assuming that decisions regarding saving have already been finalized and have no impact on the allocation of consumption expenditure across commodity groups. Such a formulation may not be appropriate, especially for a model incorporating dynamic elements, as the level and purpose of savings may in fact be reflected in and affected by the allocation of consumption expenditure. Such would be the case, for example, if the consumer decided to reduce present purchases from certain groups in order to permit savings for subsequent purchase of, say, a large durable item. Incorporation of these considerations into the model might result in more precise and more reasonable empirical estimates.

Short- and Long-run Elasticities

Although the estimated parameters of the partially dynamic model are not entirely satisfactory, they nevertheless imply certain dynamic behavioral responses to changes in prices and income. In the short run, the state variables s_i are by definition unresponsive to changes in prices and income, and income and price elasticities may be derived by assuming that,

$$\frac{\partial s_i}{\partial Y} = 0 \quad \text{and} \quad \frac{\partial s_i}{\partial P} = 0$$

Long-run equilibrium, in contrast, is described by the condition that the state variables are no longer changing over time. The implications of this condition may be derived by setting $\dot{s}_i$ of equation (25) equal to zero, and working through the formula for income and price elasticities.

The short-term results are especially interesting from an economic point of view, since they presumably relate more closely to the dynamic process of adjustment reflected in most real world economic reactions. Short-run elasticities may be derived by applying the above assumptions about unresponsiveness of the state variables to the partially dynamic version of the linear expenditure system presented in equation (28). The short-run income elasticity of demand for commodity i is then derived from the demand equation implied by equation (28) as:

$$\eta_i^s = \frac{\partial x_i}{\partial Y} \cdot \frac{Y}{x_i} = \frac{\beta_i}{P_i \Sigma\beta_i} \cdot \frac{Y}{x_i} = \frac{Y}{P_i x_i} \cdot \frac{\beta_i}{\Sigma\beta_i} \tag{35}$$

which, if the β_i's are normalized, exactly corresponds to the formula derived for the static model (although estimates must of necessity differ due to the different constraints imposed on the two systems).

Derivation of an expression for the short-term own-price elasticity of demand for commodity i is slightly more complicated, due to the presence in equation (28) of the unobservable state variable, s_i. Application of the general formula for own-price elasticity of demand gives:

$$\varepsilon^{s}_{ii} = \frac{\partial x_i}{\partial P_i} \cdot \frac{P_i}{x_i} = \frac{-\beta_i \; (Y - \Sigma_j P_j(\Theta_j + \alpha_j s_j))}{P_i^{\,2} \; \Sigma\beta_i} \cdot \frac{P_i}{x_i}$$

$$= \frac{-\beta_i (Y - \Sigma_j P_j(\Theta_j + \alpha_j s_j))}{P_i x_i \; \Sigma\beta_i} \qquad (36)$$

Unfortunately, this expression includes the unobservable variables, s_i, and thus is not amenable to direct calculation. The problem is resolved, however, by reference to the value of λ presented in statement (27) above. Thus, expression (36) is equivalent to

$$\varepsilon^{s}_{ii} = \frac{-\beta_i}{\lambda P_i x_i} \qquad (37)$$

The unobservable variables, s_i, have been substituted by the marginal utility of income, λ, for which a series was derived during the estimation process.

The presence of the unobservable state variables also complicates the calculation of cross-price elasticities of demand. The general formula for such elasticities results in the present case in:

$$\varepsilon^{s}_{ij} = \frac{\partial x_i}{\partial P_j} \cdot \frac{P_j}{x_i} = \frac{-\beta_i \; (\Theta_j + \alpha_j s_j)}{P_i \Sigma \beta_i} \cdot \frac{P_j}{x_i} = \frac{-\beta_i P_j (\Theta_j + \alpha_j s_j)}{P_i x_i \; \Sigma \beta_i}$$

Unfortunately, elimination of the unobservable state variables is not feasible in this instance, and the short-run cross-price elasticities implied by the partially dynamic model cannot be calculated.

The short-term income and price elasticity estimates for the partially dynamic model applied to Florida are presented in Table 10. All elasticities were evaluated for mean values of prices and expenditure, using the formulations of statements (35) and (37) above. For convenience, the corresponding results from application of the static model to Florida have been reproduced in the table as well.

There are several anomalies in these estimates. First, income and price elasticities associated with the groups of clothing and shoes and housing (for which the estimated coefficients were not significantly different from zero) are of the wrong sign, and thus are not reasonable from an a priori standpoint. In addition, both the income and the own-price elasticities for food and beverages are higher (in absolute terms) than for any other group, a result that is not consistent with theoretical expectations. With the exception of these three groups, however, the estimates seem to be fairly consistent; in fact, the remaining estimated income elasticities are remarkably similar to those in the Florida application of the static model, as described in the previous chapter. The pattern displayed by the estimated price elasticities also resembles closely that of the earlier model. As expected, relatively elastic responses are demonstrated by both durable goods categories, while purchases from several other groups (e.g., gasoline and oil and housing operation) appear to be less sensitive to price and income changes.

Several estimates tend to confirm differences between Florida and the United States that emerged from the static analysis of the previous chapter.

Table 10. Florida: Income and Price Elasticities
July 1968-December 1973

	η_{ii}		ε_{ii}	
	Partially Dynamic Short-term	Static	Partially Dynamic Short-term	Static
1. Automobiles and parts	1.3193	1.5767	-4.5520	-1.0209
2. Furniture, household equipment	1.4129	1.2786	-4.8747	-0.8436
3. Food and beverages	1.7014	0.5779	-5.8700	-0.4646
4. Clothing and shoes	-0.5155	0.4582	1.7784	-0.3101
5. Gasoline and oil	0.6900	0.5192	-2.3808	-0.3539
6. Housing	-0.0192	0.6099	0.0663	-0.4151
7. Housing operation	0.6130	0.9590	-2.1150	-0.6569
8. Transportation	1.1954	2.3721	-4.1245	-1.5135
9. Other	0.7712	1.1879	-2.6607	-0.8675

Sources: Tables 4 and 9.

The estimated income elasticity of demand for automobiles and parts, at about 1.3, is below the estimate of 1.6 obtained for the static model, thus adding to the earlier evidence that such demand is indeed less elastic in Florida than in the United States as a whole. The estimated income elasticity of 1.7 for food and beverages in the partially dynamic model, while clearly unacceptably large in the context of results for other categories, does tend to corroborate the previous indication that demand in this category was more elastic in Florida than in the nation as a whole during the period under consideration. Similarly, although the negative income elasticities associated with clothing and shoes are theoretically not justifiable, they do add to the evidence that demand elasticities in these categories are much smaller in Florida than in the rest of the United States. Results of the previous analysis with respect to gasoline and oil, housing operation and other unclassified, where no significant differences between the two regions were obtained, are also confirmed by the similarity of the partially dynamic and static estimates. Finally, the response estimates associated with transportation are relatively high, further corroborating the previous result indicating a much higher response for this category in Florida than in the United States as a whole. Thus, even though results for three of the nine commodity groups are unacceptable, results for the remaining six categories do appear to be fairly reasonable, and estimates for all nine categories tend to further confirm the differences between Florida and the United States that were evident from the previous analysis.

The calculated long-run elasticities for the partially dynamic model applied to Florida are less satisfactory. Long-run elasticities are derived by assuming that $\dot{s}_i$ of equation (25) is equal to zero, which implies that s_i may be stated as:

$$s_i = \frac{x_i}{\delta_i} \qquad i = 1,\ldots,n$$

Substitution into the demand equation implied by statement (28) results in the following expression,

$$x_i = \Theta_i + \frac{\alpha_i x_i}{\delta_i} + \frac{\beta_i}{P_i \Sigma\beta_i} \left(Y - \Sigma_j P_j \left(\Theta_j + \frac{\alpha_j x_j}{\delta_j}\right)\right)$$

$$i = 1,\ldots,n$$

Multiplying through by δ_i, collecting terms, and solving for x_i gives

$$x_i = \frac{\delta_i}{\left(\delta_i - \alpha_i \frac{(1 - \beta_i)}{\Sigma\beta_i}\right)} \cdot \left[\Theta_i \frac{(1 - \beta_i)}{\Sigma\beta_i} + \frac{\beta}{P_i \Sigma\beta_i} \left(Y - \sum_{i \neq j} P_j \left(\Theta_j + \frac{\alpha_j x_j}{\delta_j}\right)\right)\right] \qquad i = 1,\ldots,n \qquad (38)$$

The long-run income elasticity of demand for commodity i may then be obtained from this equation, as:

$$\eta_i^L = \frac{\partial x_i}{\partial Y} \cdot \frac{Y}{x_i} = \frac{\delta_i}{\left(\delta_i - \alpha_i \frac{(1 - \beta_i)}{\Sigma\beta_i}\right)} \cdot \frac{\beta_i}{\Sigma\beta_i} \cdot \frac{Y}{P_i x_i} \qquad (39)$$

The long-run own-price elasticity of demand for commodity i may also be derived from statement (38) as:

$$\varepsilon_{ii}^L = \frac{\partial x_i}{\partial P_i} \cdot \frac{P_i}{x_i} = \frac{-\delta_i}{\left(\delta_i - \alpha_i \frac{(1 - \beta_i)}{\Sigma\beta_i}\right)} \cdot \frac{\beta_i}{\Sigma\beta_i} \cdot \frac{\left(Y - \sum_{i \neq j} P_j \left(\Theta_j + \frac{\alpha_j x_j}{\delta_j}\right)\right)}{P_i x_i} \qquad (40)$$

Similarly, the long-run cross-price elasticity of demand for commodity i is derived as:

$$\varepsilon_{ij}^{L} = \frac{\partial x_i}{\partial P_j} \cdot \frac{P_j}{x_i} = \frac{-\delta_i}{(\delta_i - \alpha_i(1 - \frac{\beta_i}{\Sigma\beta_i}))} \quad \frac{\beta_i}{\Sigma\beta_i} \quad \cdot \quad \frac{P_j\ (\Theta_j + \frac{\alpha_j x_j}{\delta_j})}{P_i x_i} \qquad (41)$$

The long-term elasticities derived from the estimated structural parameters of the partially dynamic model according to statements (39), (40), and (41) are shown in Table 11. Acceptance of the estimates would imply a generally very inelastic response of purchases within most categories to movements in prices and incomes. Indeed, the estimates would indicate that long-term responses were for the most part much more inelastic than short-term reactions. This result is not intuitively obvious, but may be quite reasonable for the broad categories analyzed in this study, as there may in fact be no substitutes in the long run for such comprehensive groups.

The long-term results may also be a result of imprecision in the estimates of the underlying regression coefficients. Several possible reasons for such imprecision have been described above. In addition, the parameters required to estimate the short-run responses appear to have been estimated more efficiently than other coefficients of the model. As may

Table 11. Florida: Long-run Elasticities of the Partially Dynamic Model
July 1968-December 1973

	η_i	ε_{ij}								
		1	2	3	4	5	6	7	8	9
1. Automobiles and parts	0.0847	-0.3589	0.1056	0.0160	0.0821	0.0350	0.0066	-0.1375	0.0748	0.0521
2. Furniture, household equipment	0.1879	0.0199	-0.8616	0.0067	0.0346	0.0147	0.0027	-0.0579	0.0315	0.0219
3. Food and beverages	0.0286	0.1773	0.3957	-0.0775	0.3076	0.1312	0.0247	-0.5150	0.2803	0.1951
4. Clothing and shoes	0.1463	-0.0076	-0.0169	-0.0025	-0.7178	-0.0056	-0.0010	0.0220	-0.0120	-0.0083
5. Gasoline and oil	0.0624	0.0066	0.0148	0.0022	0.0115	-0.2954	0.0009	-0.0193	0.0105	0.0073
6. Housing	0.0117	-0.0038	-0.0084	-0.0012	-0.0065	-0.0028	-0.0569	0.0110	-0.0060	-0.0041
7. Housing operation	-0.2436	0.0068	0.0153	0.0023	0.0119	0.0050	0.0009	1.1585	0.0108	0.0075
8. Transportation	0.1333	0.0072	0.0162	0.0024	0.0126	0.0053	0.0010	-0.0211	-0.6304	0.0080
9. Other	0.0927	0.0678	0.1514	0.0230	0.1177	0.0502	0.0094	-0.1971	0.1072	-0.3722

Source: Table 9.

be observed from the elasticities formula presented earlier, calculation of the short-run elasticities requires only estimates of the β_i's and of λ, while the long-run results utilize in addition the estimated α_i's, δ_i's, and Θ_i's. The negativity of all α_i's, which was mentioned earlier, may account for some of the long-term results, as both income and price elasticities would be reduced by a negative α_i. In addition, the δ_i's and Θ_i's are in general subject to rather large standard errors, which will have considerable impact on at least the price elasticity estimates.

In any case, the overall long-term results are not entirely satisfactory, and the success of application of the partially dynamic model to Florida is at best limited. Although the short-term results did lend some support to conclusions derived from the static model of the previous chapter, the long-term results are much more ambiguous. Efforts to date to obtain more precise estimates of the coefficients have not met with success.

In spite of these difficulties, the partially dynamic model remains of considerable theoretical interest, as it does represent a much more complete and realistic depiction of real world economic processes. Even more realism is sought in the fully dynamic model that is presented in the appendix to this study. Essentially, the analysis rests on further elaboration of the basic dynamic model that has been the foundation for the work just described, but with several important modifications to allow introduction of some additional dynamic considerations.

Summary and Conclusions

This chapter has extended the static model presented earlier to incorporate a number of dynamic considerations affecting the consumer's process of adjustment to disturbances in his economic environment. In particular, the response of the consumer to changed economic circumstances was viewed as conditioned by the presence in the utility function of state variables representing stocks of durable goods or the existence of habits affecting consumption of nondurable items. A partially dynamic model incorporating such influences, developed by Phlips ([45], [46]), was applied to the Florida data base described in Chapter II.

Empirical results from estimation of the partially dynamic model may be analyzed from either a short- or a long-run frame of reference. The short run is defined here as characterized by rigidity of certain parameters (in this case the state variables) in response to changes in prices and/or income. Estimated income and price elasticities of demand derived under these conditions, while not entirely satisfactory on several grounds, were not inconsistent with corresponding estimates derived for Florida within the context of the earlier static model. In particular, the static evidence that elasticity of demand is lower in Florida than in the United States for certain items (automobiles and parts, clothing and shoes, housing) is corroborated by the partially dynamic short-term results. The same is true of the previous indications of relatively large responsiveness in Florida of expenditures during the sample period for transportation services and for food and beverages. The apparent differences between Florida and the United States that emerged from the earlier static analysis thus seem to be fairly robust in the context of short-term responses estimated for the partially dynamic model.

The long-run equilibrium in the model is defined by the condition that the state variables remain unchanged over time. Income and price elasticities of demand calculated under this condition were in general more difficult to analyze; the estimated long-term elasticities are all considerably smaller than their partially dynamic counterparts, a result that does not appear to be consistent with intuitive expectations. However, due to the aggregated nature of the groups under consideration, such a result may be entirely plausible, and in fact, is probably to be expected. The long-term results may also be related to the imprecision of some estimated parameters which do not enter into determination of short-term responses. In addition, it is possible that all of the assumptions of the model may not have been fulfilled over the particular span of time covered by the sample period. In particular, as the period was one of widely varying inflation rates, the assumption of a constant rate of depreciation may not have been appropriate. The estimation technique used for empirical application of the model also may have led to inferior results.

CHAPTER V
CONCLUSION

This study was prompted by the observation that the state of Florida has a number of characteristics that distinguish it from other areas of the United States. A temperate climate and a large tourist industry combine with a high concentration of retired persons and a number of other elements to produce an economic environment that appears to be quite different from that prevailing in many other states. Clearly, formation of economic policy in Florida should take into account the particular consumer and producer responses to various stimuli that such a special environment might engender. In the elaboration of regional or local policies, it is not enough to rely on economic parameters that have been estimated for larger regions or for the nation as a whole; it must also be demonstrated that these parameters remain appropriate for the particular subregional area of interest. The main purpose of the present study has been the examination of possible discrepancies between the State of Florida and the entire United States with regard to the responsiveness of consumers to changes in prices and income. As has been described in the preceding chapters, the statistical evidence does seem to suggest the existence of significant differences between the two regions.

Summary

Formally, statistical discrepancies between a state and the nation of which it is a part may be due either to aggregation bias or to loss of information about regional peculiarities as a normal part of the grouping process. To examine whether these factors are important in the case of Florida, this study has examined empirically the responses of consumers in the two regions. As statistics are not available on consumption patterns at the state level, it was first necessary to develop a series of data on personal consumption expenditures within the State of Florida. The calculation of such a series on the basis of information from secondary sources, primarily retail sales data, was described in detail in Chapter II. These data were analyzed in the context of the linear expenditure system in Chapter III, and corresponding estimates were derived for the entire United States. On the whole, the empirical results were very satisfactory, and provided a considerable amount of insight into the relative magnitudes of responses to economic stimuli in Florida and in the United States. In brief, although there is broad similarity between the two areas in the allocation of the consumption budget, there appear to be numerous important areas of difference. Specifically, the study pointed up particularly significant variation between the two regions as regards purchases of clothing and shoes and housing, where Florida consumers evidently purchase smaller amounts of goods, but react much less readily to changes in prices or income. Purchases of transportation services, on the other hand, are apparently much more elastic in Florida than in the nation at large. Expenditures for food and beverages also demonstrated differing responses in the two regions during the period in question. All these differences are consistent with a priori expectations, and appear to stem largely from characteristics specific to Florida, such as climate, age structure of the population, and so on.

Partly in order to test the robustness of the static results just described, a dynamic version of the linear expenditure system was presented and estimated in Chapter IV. In this formulation of the model (which is due to Phlips [45]), consumers are depicted as modifying present period budget allocation decisions on the basis of the carryover effect of stocks or habits built up during previous periods. Empirical estimates based on this version of the model were derived for the state of Florida using the data series described above. Results from dynamization of the model were mixed, although most of the short-run elasticity estimates tended to corroborate differences between Florida and the United States that appeared in the static estimates. The long-term findings were somewhat ambiguous, however, and in any case provided no further evidence either substantiating or disproving the previous results.

Evaluation of Research

The present study is a useful supplement in several respects to the existing large body of empirical research on consumer demand. Its principal contribution is the provision of some evidence of difference between Florida and the United States with regard to behavioral responses of consumers to certain economic stimuli. In addition, it has outlined and made some preliminary attempts to extend this analysis to a more realistic dynamic context. Several particular aspects of the study are discussed in further detail below.

The data series developed in the context of the present study is the only existing source of information on personal consumption expenditures in Florida. It thus represents considerable improvement over the previous lack of data in this respect. One shortcoming of the present study is that the data base, the estimation of which was described in Chapter II, depends for reliability on the strength of the secondary sources from which it was derived. These sources were not always of optimal quality. On the other hand, the essential accuracy of the series is supported by the plausibility of the resulting empirical estimates. The differences between estimates for Florida and for the United States all appear to be justified, and indeed often are to be expected, on the basis of other available information.

The static linear expenditure model presented in Chapter III is a standard approach to the analysis of systems of demand equations. The main contributions of the present study in this respect are the application of the model to Florida data, and the comparative analysis of consumer demand in Florida and in the United States as a whole. The development of empirical estimates of the parameters of consumer behavior in Florida, and the designation of the commodity groups where these regional responses appear to differ substantially from national results, is potentially of considerable interest to state policymakers and other students of the Florida economy. Numerous reasons for the usefulness of additional information about the behavioral responses of Florida consumers have been presented in the foregoing chapters. In sum, the estimates should serve a very useful role in the development of economic policy prescriptions and recommendations.

In spite of their weaknesses, the empirical results presented in conjunction with the partially dynamic version of the linear expenditure system in Chapter IV are also of interest in that they tend to corroborate the differences apparent from analysis of the static model. Several shortcomings of the particular technique used to estimate this version of the system have been described earlier. The most serious of these is probably the use of the Zellner estimation procedure rather than a suitably modified version of the maximum likelihood technique applied to the static system. Estimation of the parameters of the model by such a technique, which would also have the advantage of lending itself easily to normalization of the β_i's (thereby facilitating their interpretation as marginal budget shares), would probably result in improved empirical results. A further worthwhile modification of the model, although one which would add considerably to its computational complexity, would be the explicit incorporation of the savings versus consumption decision into the theoretical framework of the model. Abstraction from this aspect of the decision-making process, as in this study, neglects many issues that are potentially of interest.

Future Research

The topics explored by the present study are quite fruitful in terms of avenues for further research. In the first instance, the estimates of personal consumption expenditures for Florida should be maintained on a current basis through the incorporation of additional data for subsequent years. The series could also be improved through the estimation of the relatively minor components of expenditure (e.g., military payments in kind) that have so far been neglected. Existing estimates of certain less exact components (e.g., legal services) might also be replaced by data derived through more sophisticated techniques. The period covered by the series could also be extended to earlier years for which less complete retail sales data are available. Further disaggregation of the data to a larger number of less comprehensive commodity groups might also be desirable.

One important area for further research is the development of improved estimates for the partially dynamic model presented in Chapter IV. As pointed out above, the estimating technique used in the present study, an iterative application of the Zellner procedure for seemingly unrelated regressions, should probably be replaced by an iterative maximum likelihood estimation technique similar to that used in estimating the static version of the model. Alternatively, one could develop a more elaborate version of the Zellner estimator that could incorporate the normalization of the β_i's, as well as any necessary adjustment for possible serial correlation. Either course of action would probably result in difficult estimation problems, but might provide more satisfactory empirical estimates. The partially dynamic model could also be used to extend the comparison of Florida and the United States that was initiated in Chapters II and III. It would be of considerable interest to discover whether or not the apparent differences between the two regions continued to be robust in a dynamic context.

Further research could also be aimed at incorporation of additional dynamic elements into the theoretical framework of the model. The partially dynamic version of the linear expenditures system presented in Chapter IV is essentially a static model that includes a variable that changes over time. Utility maximization in this formulation of the model is still based on the choice of an optimal bundle of goods in response to a set of given economic magnitudes. Ideally, a fully dynamic model would include some consideration of the impact of this choice on future utility streams. Some preliminary work to incorporate such considerations into the theoretical framework provided by the linear expenditure system is reported in an appendix to this study. Numerous avenues for future research emerge from the issues that are highlighted by this view of the budget allocation process. Should such a model prove estimable, its application to the Florida data base could provide considerable further insight into the questions examined in this study.

Finally, the analysis of consumer behavior at a subnational level should not be confined to the State of Florida. Possible discrepancies between regional and national parameters may affect many other states. Similar studies should be undertaken in their regard to determine more precisely the exact extent of these regional differences. The country is not a monolithic entity, and the incorporation of this consideration into the analysis of subnational regions should result in more accurate and complete theoretical models, better empirical estimates, and improved regional economic policies.

APPENDIX
A FULLY DYNAMIC MODEL OF CONSUMER DEMAND

The dynamic model of Chapter IV viewed the consumer as limited in his responsiveness to changes in prices and incomes by the present implications of his purchasing decisions of past periods. These decisions were permitted to affect present period budget allocation through their impact on the magnitude of state variables representing stocks of durables or the formation of habits. Thus, present behavior in the model was affected by the past, and present decisions reflected the impact of stocks and habits built up during previous periods.

Such a view of the consumer, while considerably more realistic than the purely static model described in Chapter III, remains somewhat myopic. Even though past decisions affect the present, the consumer is still perceived as making an instantaneous budget allocation decision. The model is therefore dynamic only in the very limited sense that some manifestations of past behavior (i.e., accumulated stocks and habits) enter into the present period utility function. In essence, the partially dynamic approach is still that of a static utility model onto which some dynamic considerations have been grafted [6, p. 1225]. The consumer continues to be viewed as maximizing an instantaneous utility function in which there is some influence from past decisions, but in which there is no consideration of the future.

It is only logical, however, that a consumer operating in a dynamic world will consider not only the past but also the future in making his budget allocation decisions. He will be more interested in maximizing the utility stream accruing from his entire time path of consumption purchases than in maximizing the level of utility at any given point in time. In deciding how to allocate his resources, he will consider not only the benefit to be obtained immediately, but also the effect on future well-being of present purchasing decisions. If the system is to be truly dynamic, therefore, the consumer must be viewed as maximizing an entire time stream of utility, with future benefits of present period decisions discounted at some appropriate rate. In other words, the consumer may be assumed to maximize the utility functional,

$$u = \int_0^t e^{-\phi t} u(x,s)dt \tag{42}$$

where ϕ is a factor representing the internal rate of discount or time preference relevant to the consumer, and $u(x,s)$ is the particular mathematical form chosen for the consumer utility function.[1] The consumer is viewed as choosing an optimal program of expenditures for the entire relevant future on the basis of economic information presently available to him. He thus seeks to choose an optimal path, rather than a single optimal point, in the allocation of his present (and future) expenditures. This path will be altered to reflect future changes in the economic environment relevant to the consumer, but at any point in time, he will optimize the entire future path on the basis of available information (including expectations affecting present purchasing patterns, although it may be argued that prices should reflect such factors).

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[1] This functional is fairly restrictive, as it will exhibit strong independence (a cardinal property) in terms of trade offs across time.

There are actually two separate problems faced by the consumer in choosing an optimal path of consumption expenditures. The first concerns the choice of an optimal path for the total of consumption purchases. The consumer is viewed as first determining the optimal lifetime allocation of resources between savings and consumption. The second problem is the choice of an optimal path for the allocation of total budgeted expenditures over the time period in question. The consumer may be viewed as taking as given the total amount of expendable budget determined in the choice between savings and consumption, and then allocating it across the different commodities within his choice set. The present study will concentrate on this second stage of the process, and it will be assumed that the observed amount of total consumption expenditure represents an optimal path for this variable.[1]

The Fully Dynamic Model

The particular form of statement (42) to be used for the present study may be specified by substituting for u(x,s) the special form of utility function implying the linear expenditure system, as described in equation (24), i.e.,

$$u = \int_0^t e^{-\phi t} \sum_{i=1}^{n} \beta i \log (x_i - \theta_i - \alpha_i s_i) dt \qquad (43)$$

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[1] For an interesting examination of the first part of the process, see Lluch [36].

where the variables are as defined in previous sections. This functional is to be maximized subject to the budget constraint[1] and subject to the set of constraints on the movement of the state variables over time that were presented in statement (25) above. The essential difference between this model and the partially dynamic formulation presented earlier is that the first order conditions for a constrained maximum of statement (43) must reflect the optimization of an entire time path and not merely a single value. The problem is one of intertemporal maximization, and requires the introduction of specialized optimality conditions. These conditions are obtained in the present case through an application of the theory of optimal control [52].

Optimal control theory has been applied to several types of problems in economics, especially those concerned with analysis of investment and growth [13]. New fields of application within economics are being constantly explored, including extension of the technique to the analysis of consumer behavior along the general lines described above ([1], [46], [47]). None of these studies, however, has dealt explicitly with a specific application to the linear expenditure system, although Phlips [46] and Phlips and Weiserbs [47] have examined the implications for a quadratic utility function. The main reason for this neglect, in spite of the otherwise generally superior performance of the linear expenditure system, is that the nonlinear first order conditions associated with such a system present formidable problems. Some of these difficulties will be examined below.

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[1] The budget constraint of the present model is identical to the constraint normally employed in comparative static analysis. Its appropriateness in the context of an intertemporal model is not immediately clear. Rather, a more appropriate constraint might be specified in terms of the wealth available to the consumer. As discussed above, the present analysis is concerned only with the optimal allocation of a given total consumption expenditure and not with the problem of the choice between savings and consumption. The constraint that expenditures for individual commodity groups should sum to observed total expenditure is therefore sufficient for purposes of this study.

Dynamic Path Maximization

Optimal control theory is a reformulation of the first order equilibrium conditions to an appropriate form for the description of an optimal path rather than a single optimal point. The special advantage of the approach is that the intertemporal problem of path optimization is in effect reduced to the instantaneous one of choosing at any point in time the particular budget allocation corresponding to the critical point on such a path. For consistency, of course, the relevant path should then be the same for all subsequent periods. A sufficient condition for consistency is that the discount function implied in statement (42) above be characterized by a constant rate of discount ϕ [49]. The statement of equilibrium conditions implied by this new perspective on optimal allocation of the consumer budget is simplified considerably by the additional assumption that the integral of equation (42) is taken for the interval from zero to infinity. This avoids the problem posed by a potential contribution to utility of a final level of wealth or bequest at the end of a finite time horizon. Given these assumptions, and if all functions are sufficiently smooth, then if an optimal program exists, it may be characterized by a set of necessity conditions known as the Maximum Principle [29, Chapter 14].

The Maximum Principle may be considered as an extension to dynamic optimization problems of the method of Lagrange multipliers [29, p.345].

It states that a commodity bundle will maximize the utility functional of statement (42) (subject to the relevant constraints) if there exists a set of dual or auxiliary variables such that the bundle in question maximizes the current value Hamiltonian (which must be concave in the state variables), and such that the movement of these variables over time follows a certain prescribed path.

The relevant Hamiltonian expression for the case of the linear expenditure system may be stated as:

$$H = \sum_{i=1}^{n} \beta_i \log (x_i - \theta_i - \alpha_i s_i) + \sum_{i=1}^{n} \mu_i \dot{s}_i \qquad (44)$$

where μ_i are the auxiliary variables mentioned above. The specific form of the equilibrium conditions may be obtained through application of the general results of Arrow & Kurz [1] for maximization over continuous time with an infinite horizon. In addition to the choice of decision variables to maximize the current value Hamiltonian, these conditions prescribe that the movement over time of the auxiliary variables must be described in the present case by [1, pp. 47-48]:

$$\frac{d\mu_i}{dt} = \dot{\mu}_i = \phi\mu_i - \frac{\partial H}{\partial s_i} \qquad i = 1,\ldots,n \qquad (45)$$

Maximization of H subject to the budget constraint gives two constraints in addition to the path prescribed for the auxiliary variables by statement (45). These may be stated as:

$$\frac{\partial H}{\partial x_i} = \lambda P_i \qquad \text{and} \qquad \sum_{i=1}^{n} P_i x_i = Y$$

The equilibrium conditions characterizing the initial point on an optimal path of budget allocation decisions may be summarized from the above discussion as:

$$\frac{\partial H}{\partial x_i} = \lambda P_i \qquad i = 1,\ldots,n \tag{46}$$

$$\frac{\partial H}{\partial s_i} = \phi\mu_i - \dot{\mu}_i \qquad i = 1,\ldots,n \tag{47}$$

$$\sum_{i=1}^{n} P_i x_i = Y \tag{48}$$

If these equilibrium conditions are fulfilled, and if H is concave in s, then given satisfaction of appropriate boundary conditions, the solution to this system of equations will be optimal.

The Maximum Principle implies that the consumer may reduce the intertemporal problem of the choice of an optimal path to the maximization in each period of the current value of the Hamiltonian of equation (44). This Hamiltonian, in turn, is interpreted as the sum of utility to be enjoyed immediately (i.e., $\Sigma_i \beta_i \log (x_i - \Theta_i - \alpha_i s_i)$ plus that anticipated for enjoyment (i.e., $\sum_{i=1}^{n} \mu_i \dot{s}_i$). The μ_i, as an auxiliary variable, is the implicit value attached to a marginal unit of s_i along the optimal path, and $\mu_i \dot{s}_i$ is the rate at which utility increases due to increases in the value of the state variable, s_i. The interpretation of statement (45) is similar, after substituting for H and applying the constraints (25) to obtain:

$$\dot{\mu}_i = \phi\mu_i - \left(\frac{\partial u}{\partial s_i} + \mu_i \frac{\partial \dot{s}_i}{\partial s_i}\right) = (\phi + \delta_i)\,\mu_i - \frac{\partial u}{\partial s_i}$$

The implicit value of a marginal unit of s_i (i.e., μ_i) must change over time in order to provide the consumer with a discounted reward for waiting (i.e., $\phi\mu_i$), that will compensate the loss in net satisfaction that results from the wait itself (i.e., $\frac{\partial u}{\partial s_i} + \mu_i \frac{\partial \dot{s}_i}{\partial s_i}$). The rational consumer will adjust stocks and habits through present period purchases so that these conditions are satisfied. The intertemporal problem is thus reduced to a corresponding problem within an instantaneous framework.

Equilibrium Conditions

Equilibrium conditions for the fully dynamic version of the linear expenditure system are obtained from statements (46) through (48) above.[1] Applied to the specific Hamiltonian expression of equation (44), these conditions may be specified as:

$$\frac{\partial H}{\partial x_i} = \beta_i/(x_i - \Theta_i - \alpha_i s_i) + \mu_i = \lambda P_i \qquad i=1,\ldots n \tag{49}$$

$$\frac{\partial H}{\partial s_i} = -\alpha_i\beta_i/(x_i - \Theta_i - \alpha_i s_i) - \mu_i\delta_i = \phi\mu_i - \dot{\mu}_i \qquad i = 1,\ldots n \tag{50}$$

$$Y = \sum_{i=1}^{n} P_i x_i \tag{51}$$

Combination of statements (49) and (51) provides a solution for the marginal value of income as:

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[1] The following discussion is patterned after work by Phlips [46] and by Phlips and Weiserbs [47] in dynamizing the quadratic utility function.

$$\lambda = \frac{\Sigma_i\beta_i + \Sigma_i\mu_i(x_i - \Theta_i - \alpha_i s_i)}{(Y - \Sigma_i P_i (\Theta_i + \alpha_i s_i)}$$

Substituting into (49) and simplifying gives the fully dynamic version of the linear expenditure system:

$$P_i x_i = P_i(\Theta_i + \alpha_i s_i) + \frac{\beta_i(Y - \Sigma_i P_i(\Theta_i + \alpha_i s_i)) + \mu_i(x_i - \Theta_i - \alpha_i s_i)}{\Sigma_i\beta_i + \Sigma_i\mu_i(x_i - \Theta_i - \alpha_i s_i)}$$

$$i = 1,\dots,n \qquad (52)$$

Statement (52) corresponds to equation (28) of the partially dynamic model presented above, and has all of the difficulties of that formulation. Specifically, estimation will be made difficult or impossible because of both low degrees of freedom and high multicollinearity. In addition, further problems will result from the imposition of the set of equilibrium conditions (50). The additional derivative with respect to time included in this constraint implies still another set of difference terms, further complicating problems of multicollinearity and degrees of freedom. The nonlinear equlibrium conditions also make difficult the elimination of the unobservable variables, μ_i. An alternative model similar to that used in the partially dynamic case, in which the unobservable variable, λ , is not eliminated, is now examined.

An Alternative Formulation

It is possible to postpone the imposition of the budget constraint (51), as was done in the development of estimating equations for the partially dynamic model. A finite approximation of (50) is obtained by using a first difference for the time derivative and substituting the values of μ_{it} and μ_{it-1} implied by equation (49) to obtain:

$$(\phi + \delta_i - 1)\left[\pi_{it} - \beta_i/(x_{it} - \theta_i - \alpha_i s_{it})\right] +$$

$$\left[\pi_{it-1} - \beta_i/(x_{it-1} - \theta_i - \alpha_i s_{it-1})\right] = -\alpha_i \beta_i/(x_{it} - \theta_i - \alpha_i s_{it})$$

$$i = 1,\dots,n$$

where π_{it} is equal to the product $\lambda_t P_{it}$ of statement (49). The unobservable variables μ_{it} and μ_{it-1} have now been eliminated, and the demand function for a given commodity may be derived by solving for the value of x_{it} implied therein, as:

$$x_{it} = \theta_i + \alpha_i s_{it} + \left[(\phi + \delta_i - 1)\pi_{it} + \pi_{it-1}\right.$$

$$\left. - \beta_i/(x_{it-1} - \theta_i - \alpha_i s_{it-1})\right]^{-1} (\phi + \delta_i - \alpha_i - 1)\,\beta_i$$

$$i = 1,\dots,n \qquad (53)$$

The presence of the unobservable state variables s_i renders direct estimation of equation (53) impossible in its present form.

The elimination of the state variables s_i is complicated by the nonlinear character of equation (53), but is accomplished by substitution from a finite approximation of the constraint (25). The simpler first difference approximation of this condition is utilized, i.e.,

$$s_{it} - s_{it-1} = x_{it} - \delta_i s_{it} \qquad i = 1,\dots,n \qquad (54)$$

rather than the more exact approximation demonstrated by Houthakker and Taylor [28], which was employed in analysis of the partially dynamic model. For the fully dynamic model, the less rigorous nature of this formulation is compensated by the somewhat easier calculations that follow, which are rather complex in any case.

The state variable s_{it} may be expressed from statement [54] as:

$$s_{it} = (1 + \delta_i)^{-1}x_{it} + (1 + \delta_i)^{-1}s_{it-1} \qquad i=1,\dots,n$$

The unobservable variable s_{it} may now be eliminated by substitution into equation (53). Multiplying through by the quantity $(1 + \delta_i)$ and collecting terms gives the further result that:

$$\begin{aligned}(1 + \delta_i + \alpha_i)x_{it} = \Theta_i(1 + \delta_i) + \alpha_i s_{it-1} + \big[(\phi + \delta_i - 1)\pi_{it} + \pi_{it-1} \\ - \beta_i/(x_{it-1} - \Theta_i - \alpha_i s_{it-1})\big]^{-1}(1 + \delta_i)(\phi + \delta_i - \alpha_i - 1)\beta_i \\ i=1,\dots,n \qquad (55)\end{aligned}$$

Elimination of the lagged unobservable variable s_{it-1} begins with solution of statement (55) for s_{it-1}, and is conceptually very straightforward. The only complication results from the fact that (55) is a quadratic polynomial and thus implies two possible solutions for s_{it-1}. In any case, substitution for s_{it-1} in statement (54), along with a corresponding substitution for s_{it}, results in the total elimination of the unobservable variables s_{it} from the model. The result of the exercise is a complicated equation that expresses the value x_{it} as a function of its own lagged value for the past two periods and of the current and similarly lagged values of the composite variable π_{it} $(= \lambda_t p_{it})$. The only unobservables remaining in the model are thus λ_t and its lagged values, and these could presumably be eliminated through iterative application of the budget constraint, as was done in the estimation of the partially dynamic model. The iterative imposition of the budget constraint implies, of course, that in addition to the variables explicitly incorporated into the estimating equations, consumption from any given product group must also be a function of the total level of consumption expenditure, Y, as well as the quantities consumed from all other product groups during present and past two periods.

Although the unobservable state variables may thus be eliminated in this formulation of the model, there remains a very formidable problem with respect to estimation. Specifically, since the solution of the quadratic form is not unique, there is no way to ascertain which of the possible solutions will be distinguished by the estimation process. The model is thus incomplete in the sense that it does not provide any criteria or selection rules for the determination of the correct solution. As has been pointed out by Goldfeld and Quandt [20, pp.231-232], a complete specification of the model would incorporate such a selection rule. Unfortunately, in the present state of the art, little is known about such rules and their impact on the model as a whole, although in some specific cases, appropriate rules may be derived from additional information (e.g., non-negativity or dynamic stability conditions) that may be available about the model. The development of such criteria for the present model remains an interesting topic for further research.

In the absence of such criteria, an acceptable second best solution might be to choose at any given point in time the combination of goods that maximizes the total discounted stream of utility as described in equation (43). Presumably such an allocation of the budget would approximate to a reasonable degree the initial point on an optimal path of expenditures, although in principle it is not necessary that the two bundles be identical (or even similar for that matter). Equation (43) could then be maximized subject to the budget constraint without incorporating the auxiliary variables μ or any considerations regarding their movement over time (refer to equation (45) above). The model would thus be simplified considerably and can be shown to be soluble, either by iteration or by incorporating independent observations on the value of a numeraire state variable.[1] Such an approach remains less than optimal, however, as the resulting model is no longer fully dynamic in the sense described at the beginning of this Appendix. A potentially more fruitful approach would probably be further research into the particular characteristics of the model, in an attempt to specify an additional constraint that would permit estimation of the fully dynamic model of equation (55).

Summary and Conclusions

This Appendix has developed a fully dynamic version of the linear expenditure system. The model was derived through the application of techniques derived from the theory of optimal control, which allows the consumer to be depicted as formulating present period allocation decisions on the basis of both the present effect of past decisions and the future effect of present purchases on the magnitude of state variables representing stocks or habits. In this formulation of the model, the consumer is viewed as choosing a path of purchases to maximize a stream of utility, rather than choosing a set of purchases to maximize the utility function at a single point in time.

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[1] This result has been demonstrated by Professor R.B. Roberts of the University of Florida.

Only limited success was achieved in developing the fully dynamic model, however, since it was not possible to derive proper estimating equations. The solution to the model depends on the roots of a quadratic expression, and more criteria are needed in order to distinguish between the two roots of the expression. Further research should aim at resolution of this difficulty and at development of a determinate and estimable version of this formulation of the model. Such a result might be obtained through the examination of dynamic stability criteria, or through the specification of additional constraints on consumer reactions.

The selection and application of an appropriate estimation procedure to the resulting equations would also be a project of considerable interest for future research. Estimated parameters of the model could be compared with those of the static and partially dynamic formulations to obtain some notion of the areas affected by the improved theoretical formulation of the model. In sum, there appear to be a number of fruitful avenues for research in further developing this fully dynamic version of the linear expenditure system.

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BIOGRAPHICAL SKETCH

Robert L. Sheehy was born in Baker, Oregon, in 1948. He attended the University of Oregon during 1966-70, graduating in June 1970 with B.A. degrees in Economics and in Romance Languages. From June 1970 through September 1972, he lived and worked as a teacher in Mexico. He entered graduate school at the University of Florida in September 1972, and was awarded the Master of Arts degree in Economics in June 1975. Since March 1976, he has been an economist at the International Monetary Fund in Washington, D. C.

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Jerome W. Milliman

Jerome W. Milliman, Chairman
Professor of Economics

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Ann R. Horowitz

Ann R. Horowitz
Associate Professor of Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

R. Blaine Roberts
Associate Professor of Economics

I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

Robert D. Emerson
Associate Professor of Food and
Resource Economics

This dissertation was submitted to the Graduate Faculty of the Department of Economics in the College of Business Administration and to the Graduate Council, and was accepted as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

December 1977

Dean, Graduate School